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(54) **ENHANCED IN-BAND ACTIVATION AND PROVISIONING OF DEVICES FOR OPENROAMING NETWORKS**

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H04W 48/02	(2006.01)

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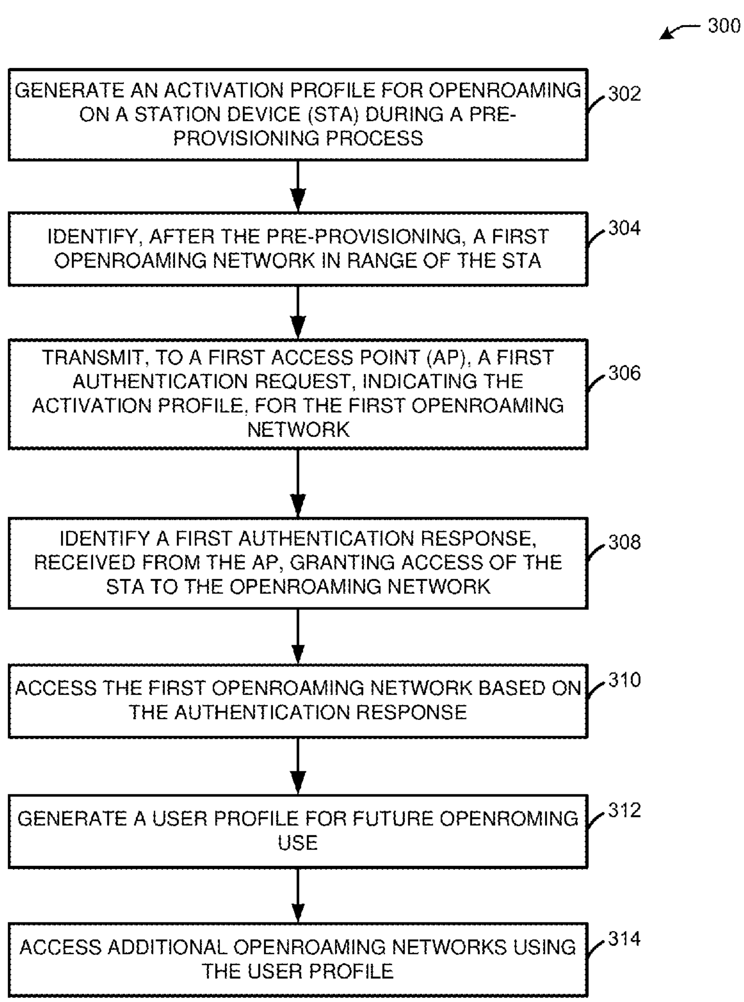
(57) **ABSTRACT**

This disclosure describes systems, methods, and devices for OpenRoaming networks. A device may be installed, during a pre-provisioning process, with an activation profile on the STA for one-time use with OpenRoaming networks; identify, after the pre-provisioning process, a first OpenRoaming network within range of the STA; transmit, to a first access point (AP), a first authentication request for the first OpenRoaming network, the first authentication request including an indication of the activation profile; identify a first authentication response received from the first AP, the first authentication request granting access of the STA to the first OpenRoaming network; and access the first OpenRoaming network based on the first authentication response. Following successful association and authentication with the OpenRoaming network, a process for establishing a user profile on the device may be triggered for future connections to OpenRoaming networks.



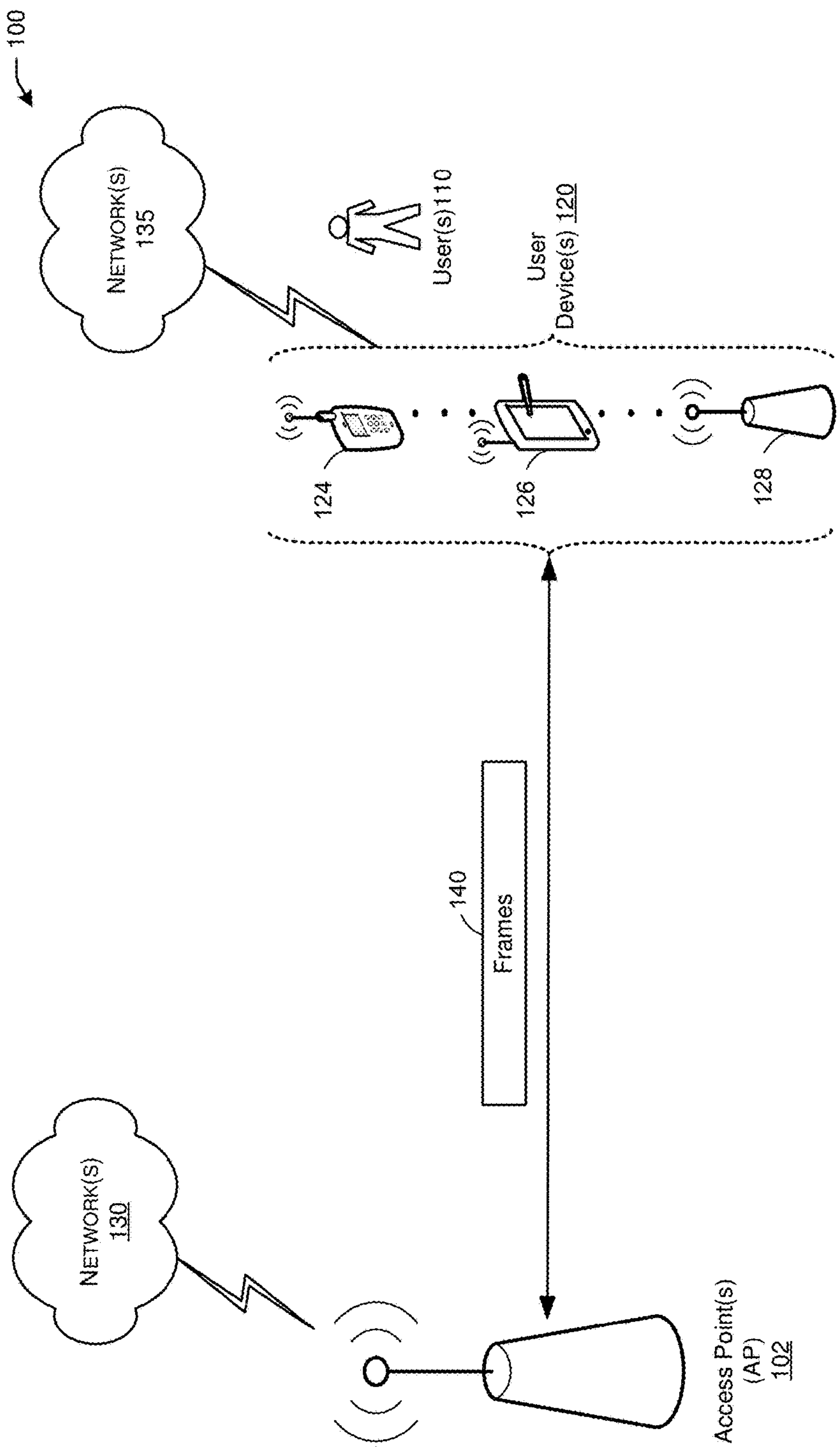

100
NETWORK(S)
135
User(s)110
User
Device(s) 120
124
126
128
140
Frames
NETWORK(S)
130
Access Point(s)
(AP)
102

FIG. 1

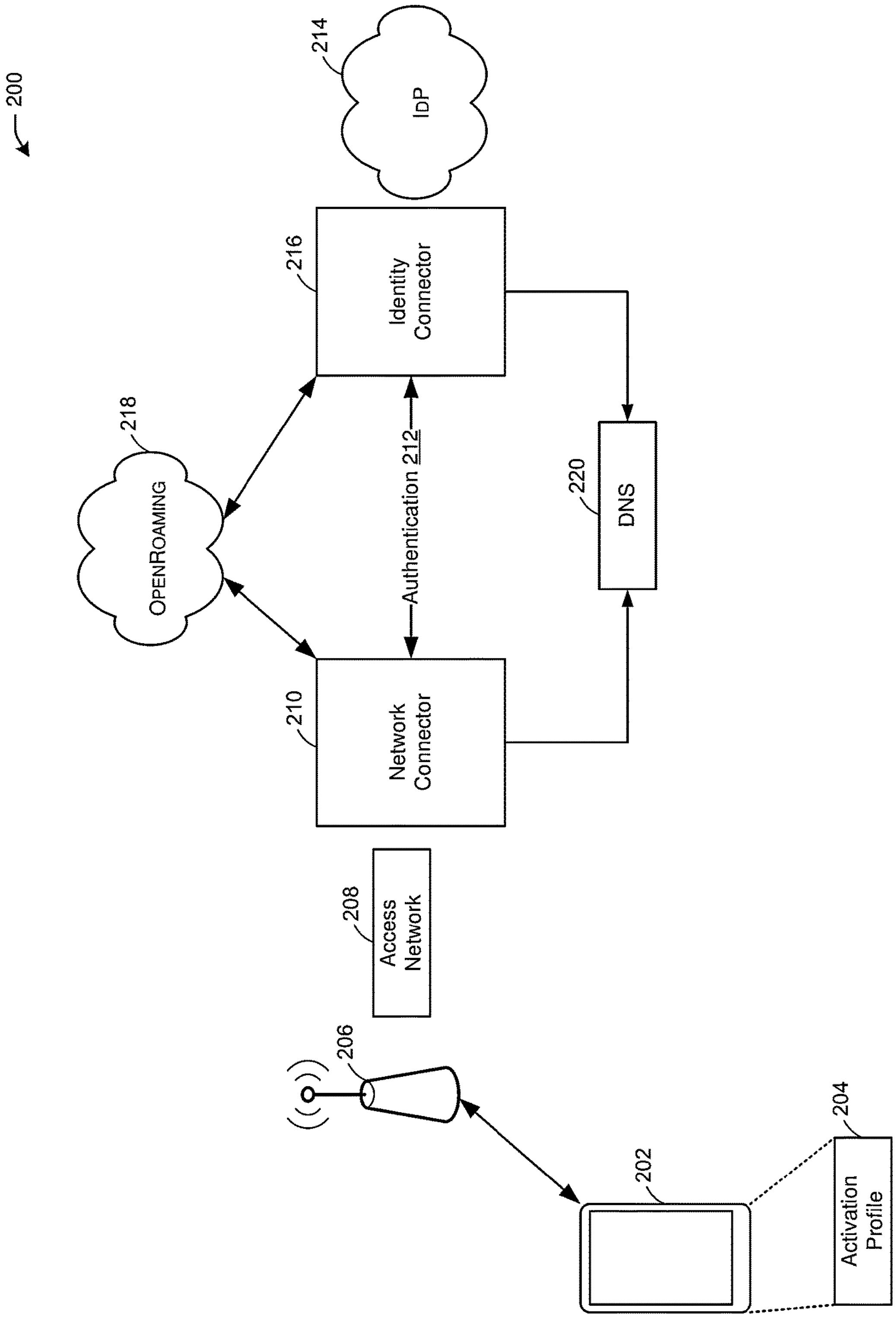

200
214
IdP
216
Identity Connector
218
OpenRoaming
Authentication 212
220
DNS
210
Network Connector
208
Access Network
206
202
204
Activation Profile

FIG. 2A

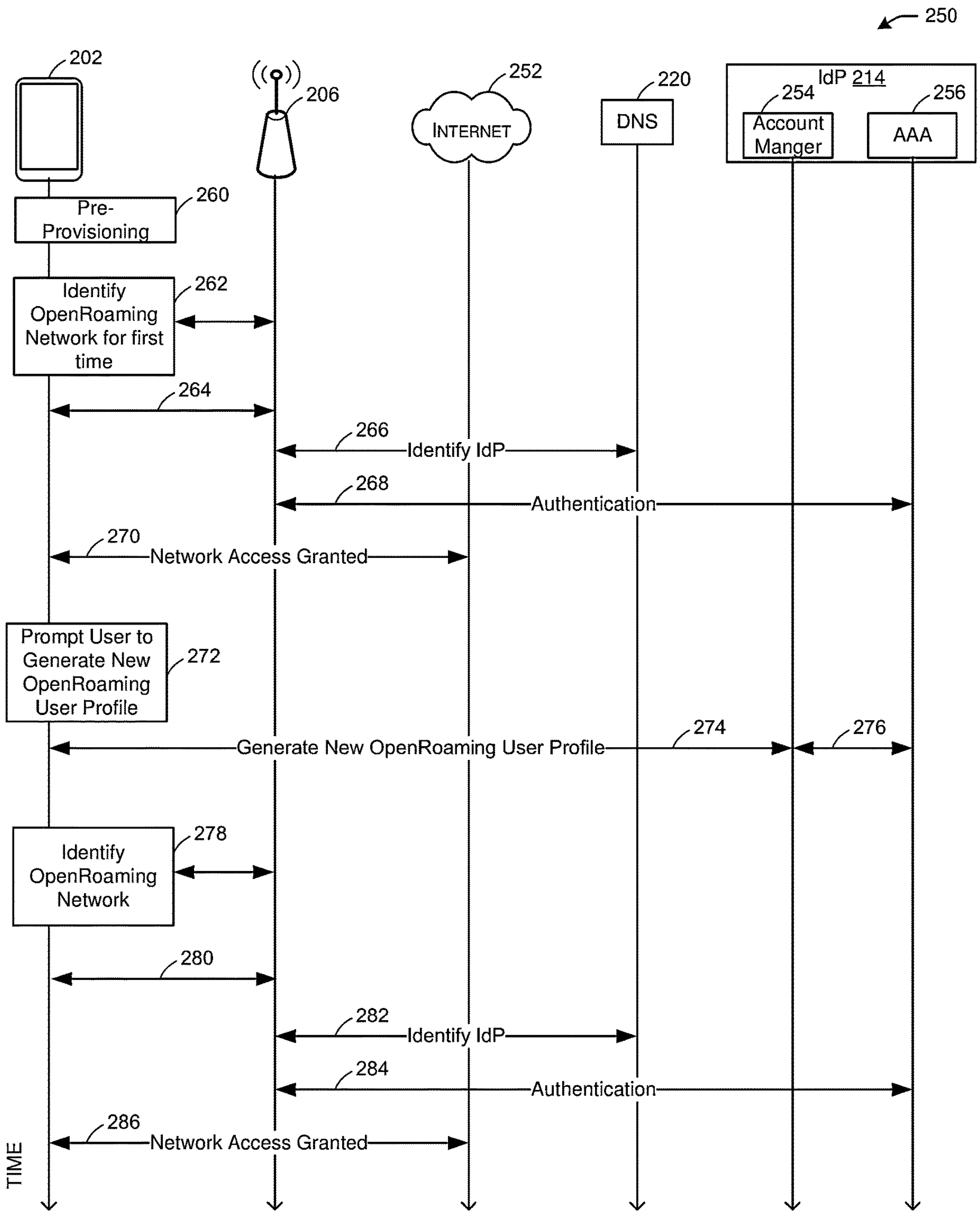

250
202
206
252
INTERNET
220
DNS
IdP 214
254
Account Manger
256
AAA
Pre-Provisioning
260
Identify OpenRoaming Network for first time
262
264
266
Identify IdP
268
Authentication
270
Network Access Granted
Prompt User to Generate New OpenRoaming User Profile
272
Generate New OpenRoaming User Profile
274
276
Identify OpenRoaming Network
278
280
282
Identify IdP
284
Authentication
286
Network Access Granted
TIME

FIG. 2B

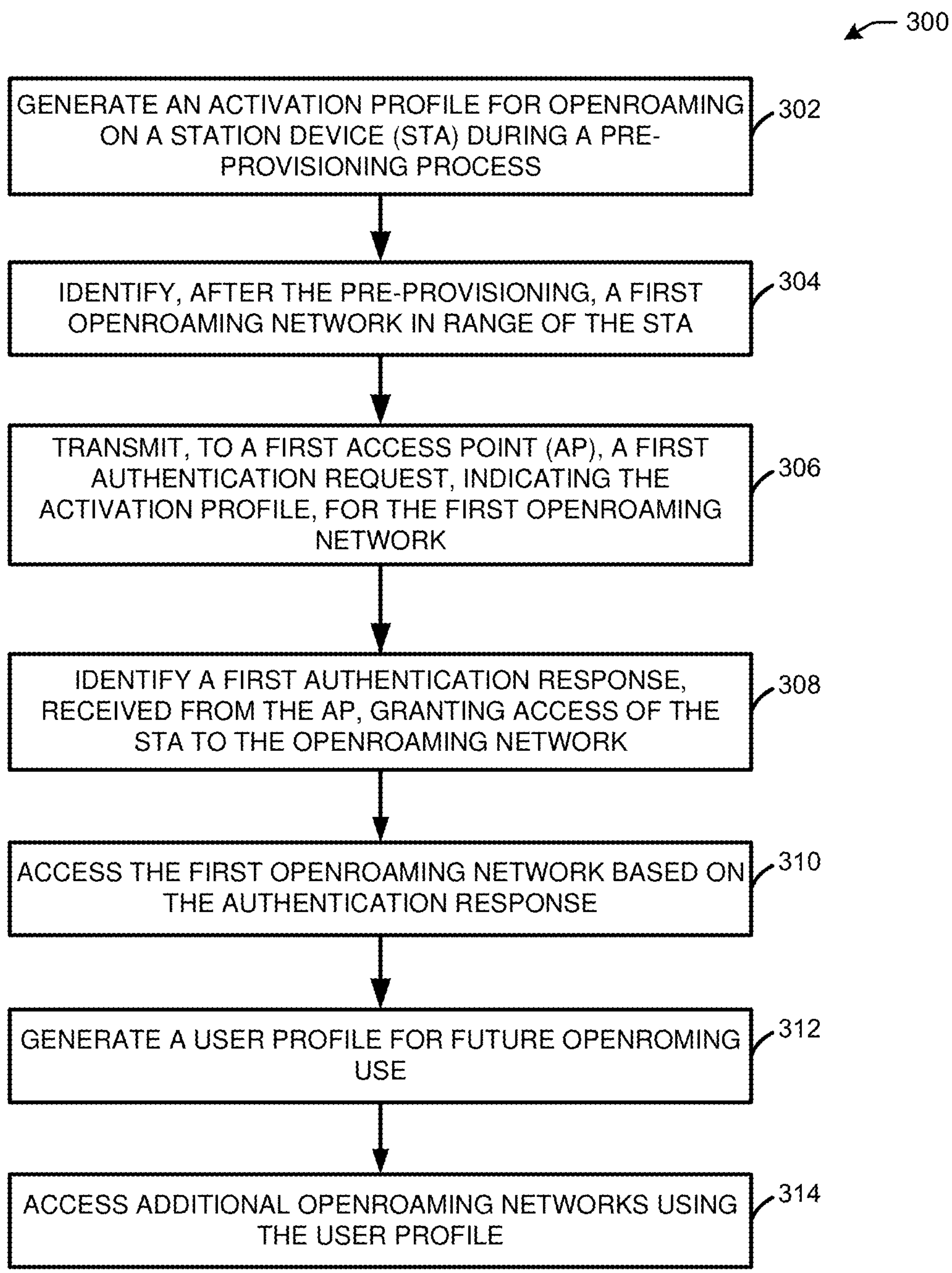

300
GENERATE AN ACTIVATION PROFILE FOR OPENROAMING ON A STATION DEVICE (STA) DURING A PRE-PROVISIONING PROCESS
302
IDENTIFY, AFTER THE PRE-PROVISIONING, A FIRST OPENROAMING NETWORK IN RANGE OF THE STA
304
TRANSMIT, TO A FIRST ACCESS POINT (AP), A FIRST AUTHENTICATION REQUEST, INDICATING THE ACTIVATION PROFILE, FOR THE FIRST OPENROAMING NETWORK
306
IDENTIFY A FIRST AUTHENTICATION RESPONSE, RECEIVED FROM THE AP, GRANTING ACCESS OF THE STA TO THE OPENROAMING NETWORK
308
ACCESS THE FIRST OPENROAMING NETWORK BASED ON THE AUTHENTICATION RESPONSE
310
GENERATE A USER PROFILE FOR FUTURE OPENROMING USE
312
ACCESS ADDITIONAL OPENROAMING NETWORKS USING THE USER PROFILE
314

FIG. 3

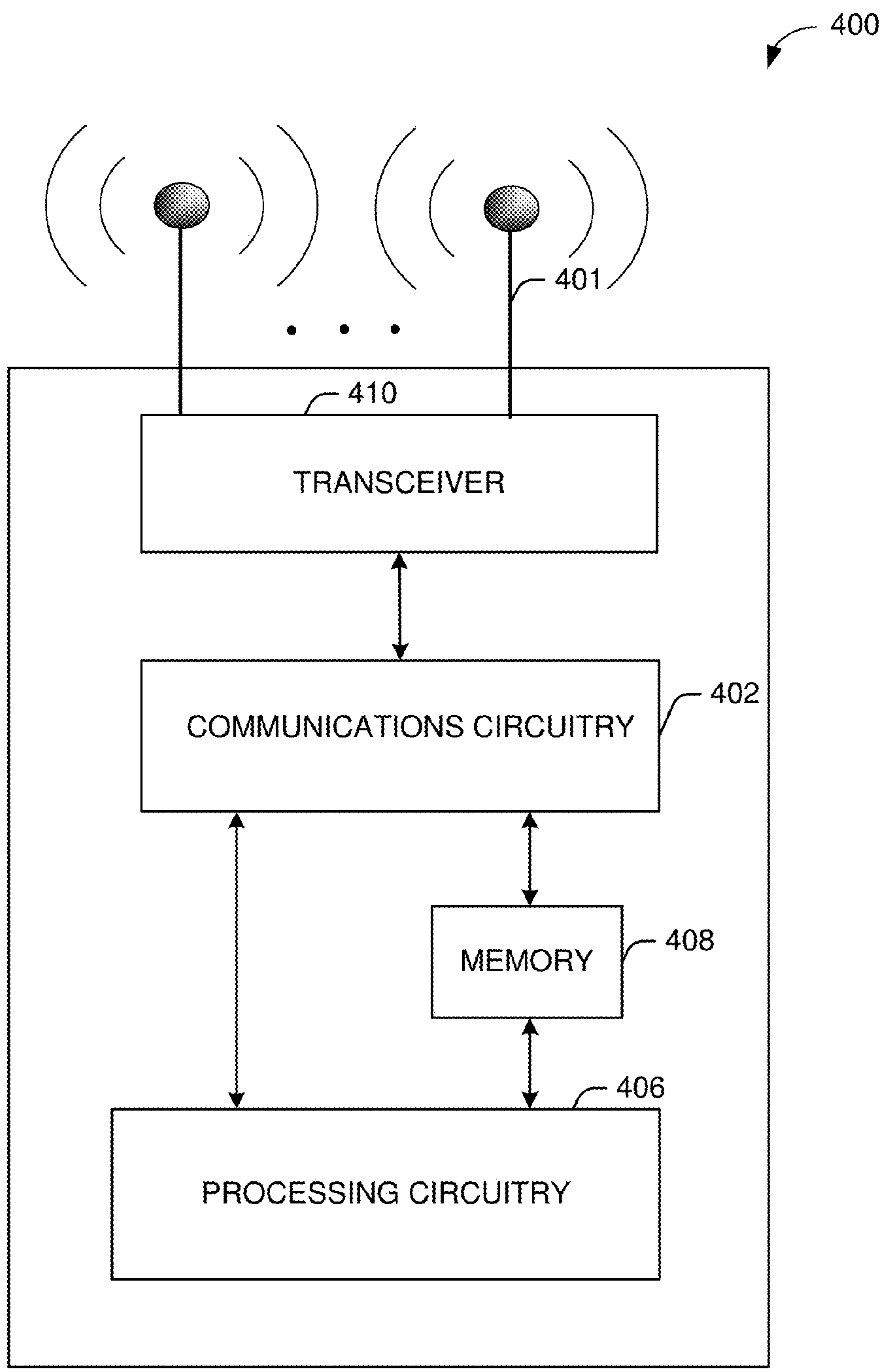

400
401
410
TRANSCEIVER
COMMUNICATIONS CIRCUITRY
402
MEMORY
408
406
PROCESSING CIRCUITRY

FIG. 4

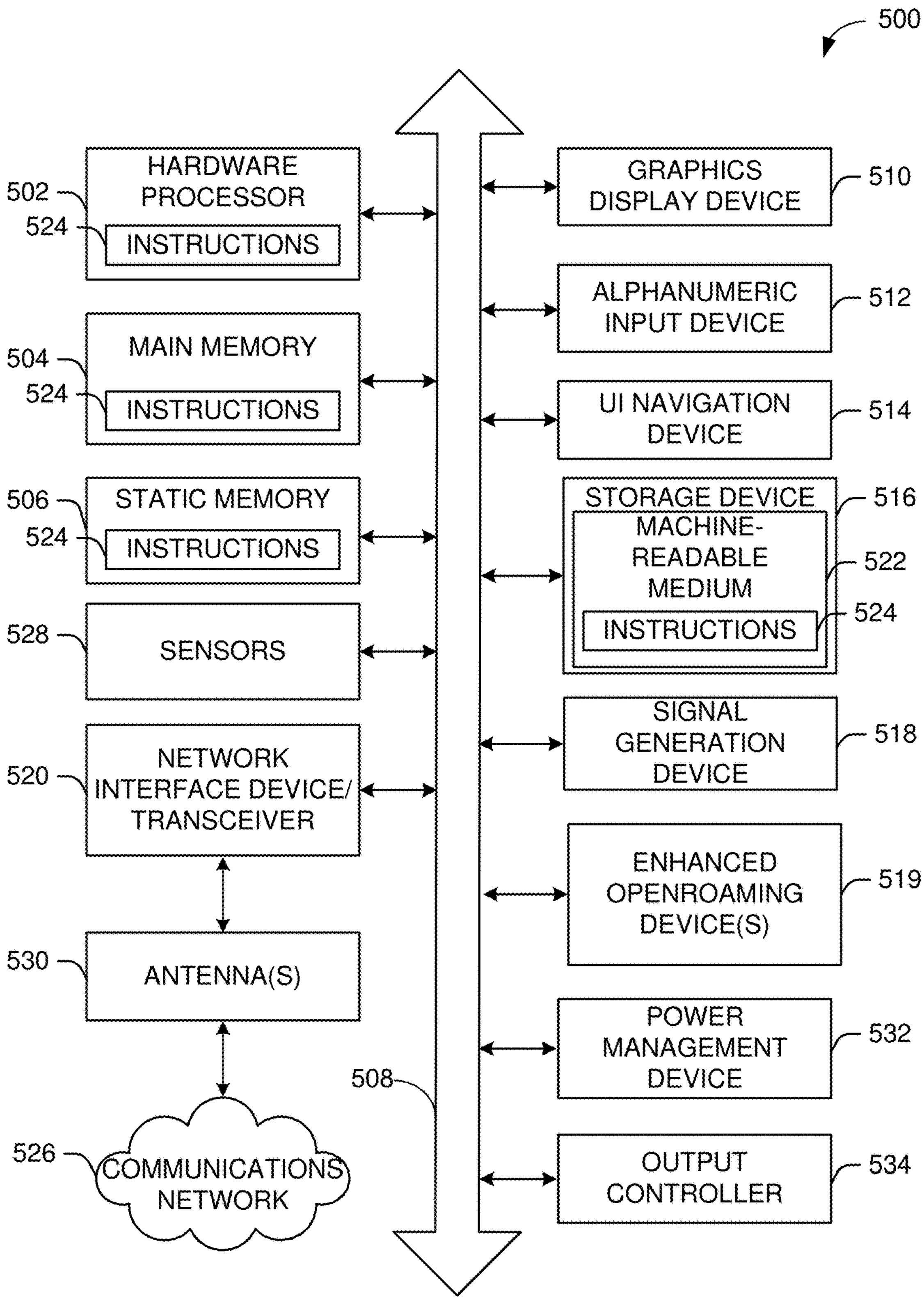

500
HARDWARE PROCESSOR
INSTRUCTIONS
502
524
MAIN MEMORY
INSTRUCTIONS
504
524
STATIC MEMORY
INSTRUCTIONS
506
524
SENSORS
528
NETWORK INTERFACE DEVICE/ TRANSCEIVER
520
ANTENNA(S)
530
COMMUNICATIONS NETWORK
526
508
GRAPHICS DISPLAY DEVICE
510
ALPHANUMERIC INPUT DEVICE
512
UI NAVIGATION DEVICE
514
STORAGE DEVICE
516
MACHINE-READABLE MEDIUM
522
INSTRUCTIONS
524
SIGNAL GENERATION DEVICE
518
ENHANCED OPENROAMING DEVICE(S)
519
POWER MANAGEMENT DEVICE
532
OUTPUT CONTROLLER
534

FIG. 5

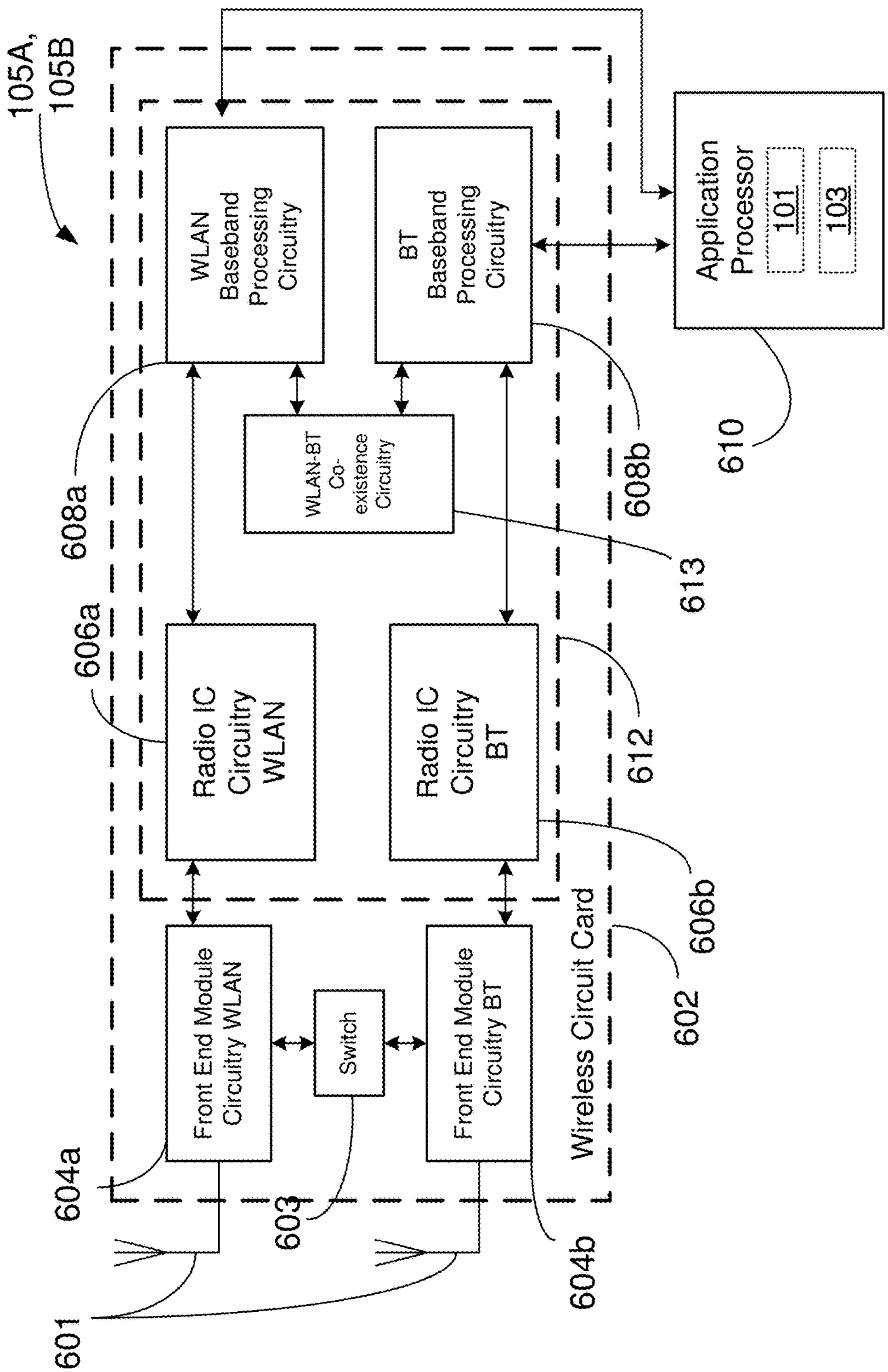

105A,
105B
WLAN
Baseband
Processing
Circuitry
BT
Baseband
Processing
Circuitry
Application
Processor
101
103
WLAN-BT
Co-
existence
Circuitry
608a
608b
610
613
606a
Radio IC
Circuitry
WLAN
Radio IC
Circuitry
BT
612
606b
Front End Module
Circuitry WLAN
Switch
Front End Module
Circuitry BT
Wireless Circuit Card
602
604a
603
604b
601

FIG. 6

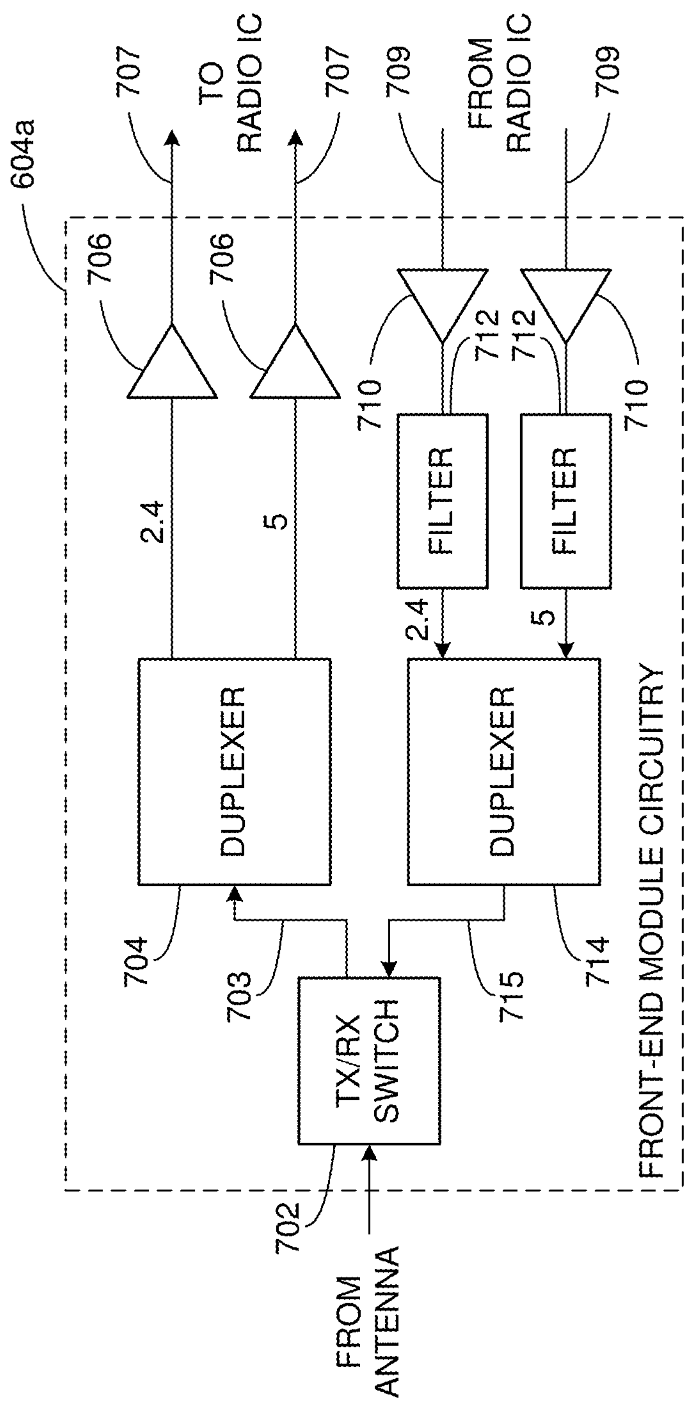

604a
707
TO RADIO IC
707
709
FROM RADIO IC
709
706
706
710
712
712
710
2.4
5
FILTER
FILTER
2.4
5
DUPLEXER
DUPLEXER
704
703
715
714
TX/RX SWITCH
FRONT-END MODULE CIRCUITRY
702
FROM ANTENNA

FIG. 7

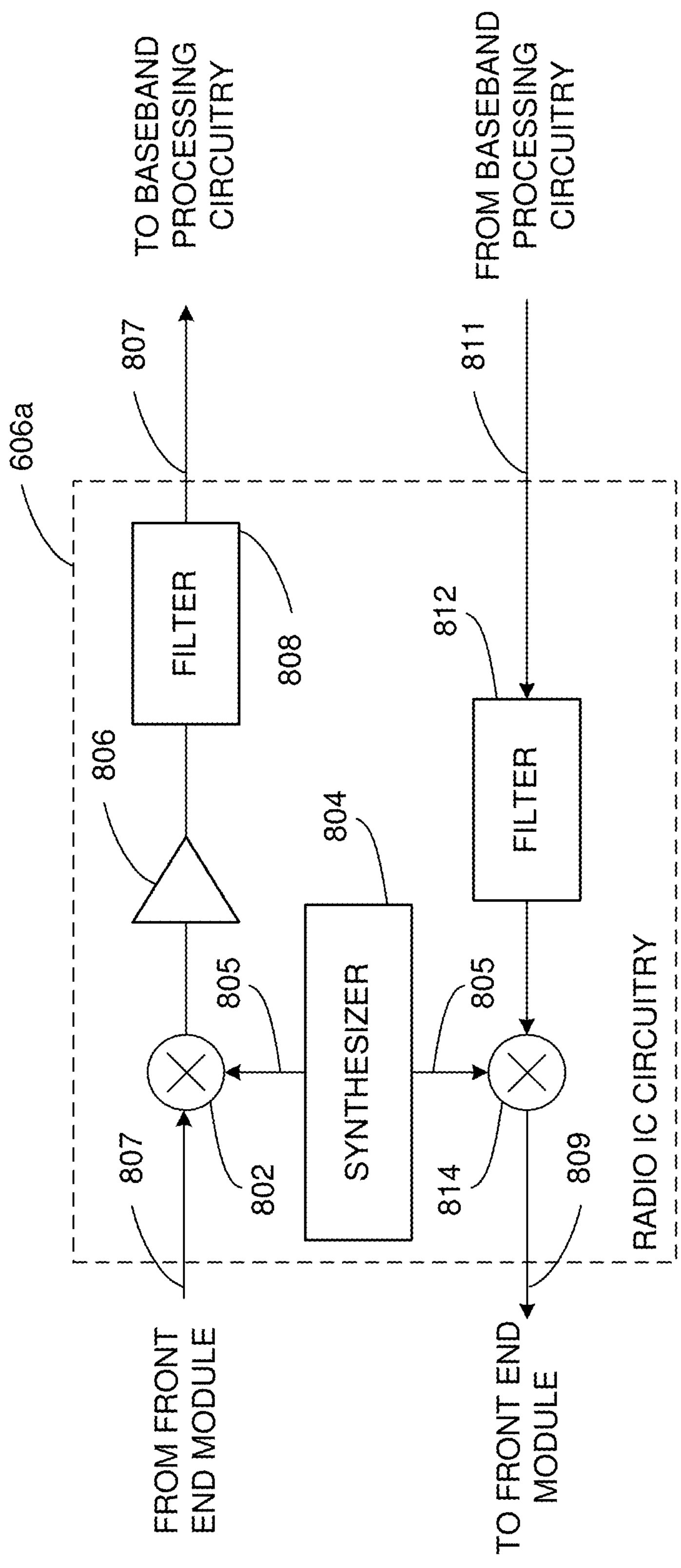

606a
TO BASEBAND PROCESSING CIRCUITRY
FROM BASEBAND PROCESSING CIRCUITRY
807
811
FILTER
808
812
806
FILTER
804
805
805
SYNTHESIZER
807
802
814
809
RADIO IC CIRCUITRY
FROM FRONT END MODULE
TO FRONT END MODULE

FIG. 8

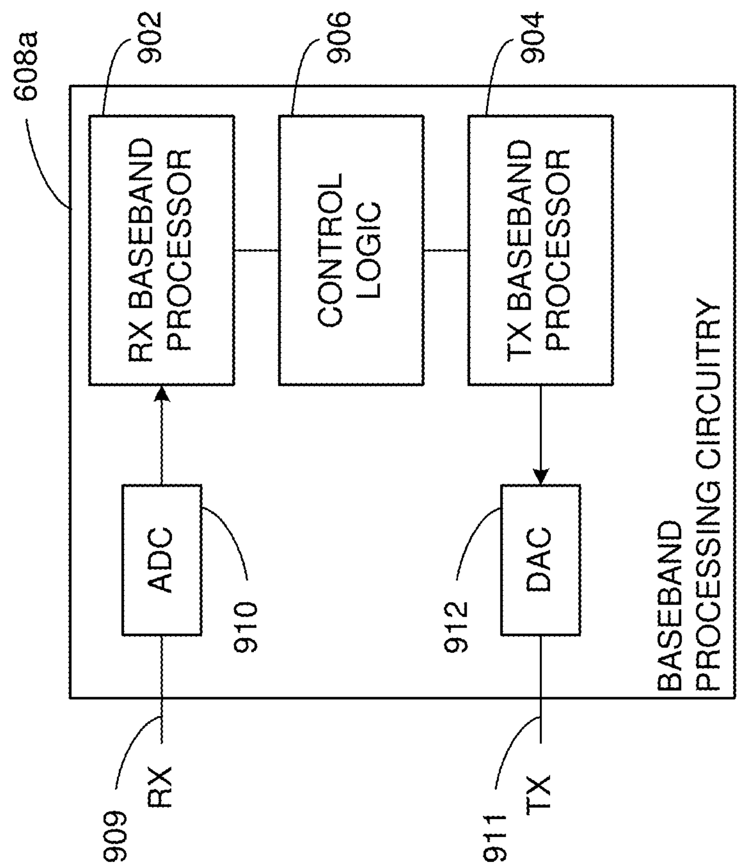

608a
902
906
904
RX BASEBAND PROCESSOR
CONTROL LOGIC
TX BASEBAND PROCESSOR
ADC
910
DAC
912
BASEBAND PROCESSING CIRCUITRY
RX
909
TX
911

FIG. 9

ENHANCED IN-BAND ACTIVATION AND PROVISIONING OF DEVICES FOR OPENROAMING NETWORKS

TECHNICAL FIELD

[0001] This disclosure generally relates to systems and methods for wireless communications and, more particularly, to enhanced in-band activation and provisioning of devices for OpenRoaming networks.

BACKGROUND

[0002] Wireless devices are becoming widely prevalent and are increasingly requesting access to wireless channels. The Institute of Electrical and Electronics Engineers (IEEE) is developing one or more standards that utilize Orthogonal Frequency-Division Multiple Access (OFDMA) in channel allocation.

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] FIG. **1** is a network diagram illustrating an example network environment, in accordance with one or more example embodiments of the present disclosure.

[0004] FIG. **2**A illustrates an example OpenRoaming™ architecture for device association, in accordance with one or more example embodiments of the present disclosure.

[0005] FIG. **2**B illustrates an example process for out-of-box OpenRoaming™ in-band activation and provisioning, in accordance with one or more example embodiments of the present disclosure.

[0006] FIG. **3** illustrates a flow diagram of illustrative process for enhanced in-band activation and provisioning of devices for OpenRoaming™ networks, in accordance with one or more example embodiments of the present disclosure.

[0007] FIG. **4** illustrates a functional diagram of an exemplary communication station that may be suitable for use as a user device, in accordance with one or more example embodiments of the present disclosure.

[0008] FIG. **5** illustrates a block diagram of an example machine upon which any of one or more techniques (e.g., methods) may be performed, in accordance with one or more example embodiments of the present disclosure.

[0009] FIG. **6** is a block diagram of a radio architecture in accordance with some examples.

[0010] FIG. **7** illustrates an example front-end module circuitry for use in the radio architecture of FIG. **6**, in accordance with one or more example embodiments of the present disclosure.

[0011] FIG. **8** illustrates an example radio IC circuitry for use in the radio architecture of FIG. **6**, in accordance with one or more example embodiments of the present disclosure.

[0012] FIG. **9** illustrates an example baseband processing circuitry for use in the radio architecture of FIG. **6**, in accordance with one or more example embodiments of the present disclosure.

DETAILED DESCRIPTION

[0013] The following description and the drawings sufficiently illustrate specific embodiments to enable those skilled in the art to practice them. Other embodiments may incorporate structural, logical, electrical, process, algorithm, and other changes. Portions and features of some embodiments may be included in, or substituted for, those of other embodiments. Embodiments set forth in the claims encompass all available equivalents of those claims.

[0014] The IEEE 802.11 technical standards define wireless communications, including the way that Wi-Fi devices access wireless communication channels. In addition, the Wireless Broadband Alliance (WBA) OpenRoaming™ is a roaming initiative for Wi-Fi devices. Unlike roaming for cellular devices, Wi-Fi devices moving between physical locations may come within many wireless local area networks (WLANs) having different connection mechanisms such as captive portals, open networks, Passpoint®, etc. The many different transitions between WLANs may be inefficient in Wi-Fi as devices move. In addition, some existing techniques have not scaled due to deployment complexity and device implementation challenges, and some existing techniques rely on a manual process with tedious user involvement.

[0015] WBA OpenRoaming™ enables Wi-Fi devices to connect to Wi-Fi networks seamlessly and securely as the devices move. WBA OpenRoaming™ is a cloud-based federation of Access Network Providers (ANPs) and Identity providers (IdPs), and is intended to simplify Wi-Fi roaming by enabling user devices to connect to OpenRoaming™ networks transparently.

[0016] An important issue with OpenRoaming™ is the provisioning of devices. While OpenRoaming™ addresses roaming issues at a global level, mobile devices need to be ready to use OpenRoaming™ out-of-box.

[0017] Without OpenRoaming™ available credentials on a mobile device, users will be blocked from accessing OpenRoaming™ networks. Some techniques use an online user sign-up, but depend on deployment of operators to deploy the sign-up, and users need to onboard their devices manually.

[0018] There is therefore a need for enhanced in-band activation and provisioning of devices for penRoaming™ networks.

[0019] In one or more embodiments, the present disclosure defines a mechanism for in-band activation and provisioning of mobile devices on OpenRoaming™ networks and enables an out-of-box OpenRoaming™-ready solution for devices. The mechanism facilitates pre-provisioning of devices for out-of-box use of OpenRoaming™, meaning that the first time that a device detects an OpenRoaming™ network, the device may associate and authenticate to the OpenRoaming™ network with an activation profile pre-provisioned on the device. The mechanism also facilitates in-band provisioning of Wi-Fi devices for OpenRoaming™.

[0020] In one or more embodiments, instead of users needing to onboard their devices for each network separately, OpenRoaming™ offers the ability to identify one global network a priori and provides ability to leverage globally available network information, allowing mobile devices to be ready for OpenRoaming™ use out-of-box. Once the device has an OpenRoaming™ profile, the device may connect to an OpenRoaming™ network. In this manner, by pre-provisioning a device with a single-use OpenRoaming™ activation profile out-of-box, the device automatically may connect to an OpenRoaming™ network when one is detected, without the user needing to first create a profile for connectivity.

[0021] In one or more embodiments, when the one-time activation profile is used to connect a device to a network, a back-end that performs user identity authentication based on the profile may determine that the profile used to join a network is a one-time activation profile. In response, the back-end may not authenticate an activation profile if the activation profile already has been used for authentication. An agent (e.g., application) on the user device (e.g., front end) may detect an OpenRoaming™ network and request authentication using the activation profile, with no user involvement required. Once authenticated using the activation profile, the agent may prompt the user, via the device, to create an updated user profile (e.g., username and password, user account details) for future use to authenticate to other OpenRoaming™ networks. Once the user's profile has been generated, the device automatically can join OpenRoaming™ networks that it detects by using the user profile that has been created.

[0022] In one or more embodiments, the activation profile may be generated during device manufacturing (e.g., prior to sale/purchase of the device). The activation profile may include a device identifier, a medium access control (MAC) address, a certificate and/or a token, and may be installed on the device during a fresh system setup on the device. When the device performs a system update, it may verify that it has an OpenRoaming™ profile. When the profile exists on the device, the device may skip the OpenRoaming™ pre-provisioning.

[0023] The above descriptions are for purposes of illustration and are not meant to be limiting. Numerous other examples, configurations, processes, algorithms, etc., may exist, some of which are described in greater detail below. Example embodiments will now be described with reference to the accompanying figures.

[0024] FIG. **1** is a network diagram illustrating an example network environment, in accordance with one or more example embodiments of the present disclosure.

[0025] Wireless network **100** may include one or more user devices **120** and one or more access points(s) (AP) **102**, which may communicate in accordance with IEEE 802.11 communication standards. The user device(s) **120** may be mobile devices that are non-stationary (e.g., not having fixed locations) or may be stationary devices.

[0026] In some embodiments, the user devices **120** and the AP **102** may include one or more computer systems similar to that of the functional diagram of FIG. **4** and/or the example machine/system of FIG. **5**.

[0027] One or more illustrative user device(s) **120** and/or AP(s) **102** may be operable by one or more user(s) **110**. It should be noted that any addressable unit may be a station (STA). An STA may take on multiple distinct characteristics, each of which shape its function. For example, a single addressable unit might simultaneously be a portable STA, a quality-of-service (QoS) STA, a dependent STA, and a hidden STA. The one or more illustrative user device(s) **120** and the AP(s) **102** may be STAs. The one or more illustrative user device(s) **120** and/or AP(s) **102** may operate as a personal basic service set (PBSS) control point/access point (PCP/AP). The user device(s) **120** (e.g., **124**, **126**, or **128**) and/or AP(s) **102** may include any suitable processor-driven device including, but not limited to, a mobile device or a non-mobile, e.g., a static device. For example, user device(s) **120** and/or AP(s) **102** may include, a user equipment (UE), a station (STA), an access point (AP), a software enabled AP (SoftAP), a personal computer (PC), a wearable wireless device (e.g., bracelet, watch, glasses, ring, etc.), a desktop computer, a mobile computer, a laptop computer, an ultrabook™ computer, a notebook computer, a tablet computer, a server computer, a handheld computer, a handheld device, an internet of things (IoT) device, a sensor device, a PDA device, a handheld PDA device, an on-board device, an off-board device, a hybrid device (e.g., combining cellular phone functionalities with PDA device functionalities), a consumer device, a vehicular device, a non-vehicular device, a mobile or portable device, a non-mobile or non-portable device, a mobile phone, a cellular telephone, a PCS device, a PDA device which incorporates a wireless communication device, a mobile or portable GPS device, a DVB device, a relatively small computing device, a non-desktop computer, a "carry small live large" (CSLL) device, an ultra mobile device (UMD), an ultra mobile PC (UMPC), a mobile internet device (MID), an "origami" device or computing device, a device that supports dynamically composable computing (DCC), a context-aware device, a video device, an audio device, an A/V device, a set-top-box (STB), a blu-ray disc (BD) player, a BD recorder, a digital video disc (DVD) player, a high definition (HD) DVD player, a DVD recorder, a HD DVD recorder, a personal video recorder (PVR), a broadcast HD receiver, a video source, an audio source, a video sink, an audio sink, a stereo tuner, a broadcast radio receiver, a flat panel display, a personal media player (PMP), a digital video camera (DVC), a digital audio player, a speaker, an audio receiver, an audio amplifier, a gaming device, a data source, a data sink, a digital still camera (DSC), a media player, a smartphone, a television, a music player, or the like. Other devices, including smart devices such as lamps, climate control, car components, household components, appliances, etc. may also be included in this list.

[0028] As used herein, the term "Internet of Things (IoT) device" is used to refer to any object (e.g., an appliance, a sensor, etc.) that has an addressable interface (e.g., an Internet protocol (IP) address, a Bluetooth identifier (ID), a near-field communication (NFC) ID, etc.) and can transmit information to one or more other devices over a wired or wireless connection. An IoT device may have a passive communication interface, such as a quick response (QR) code, a radio-frequency identification (RFID) tag, an NFC tag, or the like, or an active communication interface, such as a modem, a transceiver, a transmitter-receiver, or the like. An IoT device can have a particular set of attributes (e.g., a device state or status, such as whether the IoT device is on or off, open or closed, idle or active, available for task execution or busy, and so on, a cooling or heating function, an environmental monitoring or recording function, a light-emitting function, a sound-emitting function, etc.) that can be embedded in and/or controlled/monitored by a central processing unit (CPU), microprocessor, ASIC, or the like, and configured for connection to an IoT network such as a local ad-hoc network or the Internet. For example, IoT devices may include, but are not limited to, refrigerators, toasters, ovens, microwaves, freezers, dishwashers, dishes, hand tools, clothes washers, clothes dryers, furnaces, air conditioners, thermostats, televisions, light fixtures, vacuum cleaners, sprinklers, electricity meters, gas meters, etc., so long as the devices are equipped with an addressable communications interface for communicating with the IoT network. IoT devices may also include cell phones, desktop computers, laptop computers, tablet computers, personal digital assistants (PDAs), etc. Accordingly, the IoT network may be comprised of a combination of "legacy" Internetaccessible devices (e.g., laptop or desktop computers, cell phones, etc.) in addition to devices that do not typically have Internet-connectivity (e.g., dishwashers, etc.).

[0029] The user device(s) **120** and/or AP(s) **102** may also include mesh stations in, for example, a mesh network, in accordance with one or more IEEE 802.11 standards and/or 3GPP standards.

[0030] Any of the user device(s) **120** (e.g., user devices **124**, **126**, **128**), and AP(s) **102** may be configured to communicate with each other via one or more communications networks **130** and/or **135** wirelessly or wired. The user device(s) **120** may also communicate peer-to-peer or directly with each other with or without the AP(s) **102**. Any of the communications networks **130** and/or **135** may include, but not limited to, any one of a combination of different types of suitable communications networks such as, for example, broadcasting networks, cable networks, public networks (e.g., the Internet), private networks, wireless networks, cellular networks, or any other suitable private and/or public networks. Further, any of the communications networks **130** and/or **135** may have any suitable communication range associated therewith and may include, for example, global networks (e.g., the Internet), metropolitan area networks (MANs), wide area networks (WANs), local area networks (LANs), or personal area networks (PANs). In addition, any of the communications networks **130** and/or **135** may include any type of medium over which network traffic may be carried including, but not limited to, coaxial cable, twisted-pair wire, optical fiber, a hybrid fiber coaxial (HFC) medium, microwave terrestrial transceivers, radio frequency communication mediums, white space communication mediums, ultra-high frequency communication mediums, satellite communication mediums, or any combination thereof.

[0031] Any of the user device(s) **120** (e.g., user devices **124**, **126**, **128**) and AP(s) **102** may include one or more communications antennas. The one or more communications antennas may be any suitable type of antennas corresponding to the communications protocols used by the user device(s) **120** (e.g., user devices **124**, **126** and **128**), and AP(s) **102**. Some non-limiting examples of suitable communications antennas include Wi-Fi antennas, Institute of Electrical and Electronics Engineers (IEEE) 802.11 family of standards compatible antennas, directional antennas, non-directional antennas, dipole antennas, folded dipole antennas, patch antennas, multiple-input multiple-output (MIMO) antennas, omnidirectional antennas, quasi-omnidirectional antennas, or the like. The one or more communications antennas may be communicatively coupled to a radio component to transmit and/or receive signals, such as communications signals to and/or from the user devices **120** and/or AP(s) **102**.

[0032] Any of the user device(s) **120** (e.g., user devices **124**, **126**, **128**), and AP(s) **102** may be configured to perform directional transmission and/or directional reception in conjunction with wirelessly communicating in a wireless network. Any of the user device(s) **120** (e.g., user devices **124**, **126**, **128**), and AP(s) **102** may be configured to perform such directional transmission and/or reception using a set of multiple antenna arrays (e.g., DMG antenna arrays or the like). Each of the multiple antenna arrays may be used for transmission and/or reception in a particular respective direction or range of directions. Any of the user device(s) **120** (e.g., user devices **124**, **126**, **128**), and AP(s) **102** may be configured to perform any given directional transmission towards one or more defined transmit sectors. Any of the user device(s) **120** (e.g., user devices **124**, **126**, **128**), and AP(s) **102** may be configured to perform any given directional reception from one or more defined receive sectors.

[0033] MIMO beamforming in a wireless network may be accomplished using RF beamforming and/or digital beamforming. In some embodiments, in performing a given MIMO transmission, user devices **120** and/or AP(s) **102** may be configured to use all or a subset of its one or more communications antennas to perform MIMO beamforming.

[0034] Any of the user devices **120** (e.g., user devices **124**, **126**, **128**), and AP(s) **102** may include any suitable radio and/or transceiver for transmitting and/or receiving radio frequency (RF) signals in the bandwidth and/or channels corresponding to the communications protocols utilized by any of the user device(s) **120** and AP(s) **102** to communicate with each other. The radio components may include hardware and/or software to modulate and/or demodulate communications signals according to pre-established transmission protocols. The radio components may further have hardware and/or software instructions to communicate via one or more Wi-Fi and/or Wi-Fi direct protocols, as standardized by the Institute of Electrical and Electronics Engineers (IEEE) 802.11 standards. In certain example embodiments, the radio component, in cooperation with the communications antennas, may be configured to communicate via 2.4 GHz channels (e.g. 802.11b, 802.11g, 802.11n, 802.11ax), 5 GHz channels (e.g. 802.11n, 802.11ac, 802.11ax), or 60 GHZ channels (e.g. 802.11ad, 802.11ay). 800 MHz channels (e.g. 802.11ah). The communications antennas may operate at 28 GHz and 40 GHz. It should be understood that this list of communication channels in accordance with certain 802.11 standards is only a partial list and that other 802.11 standards may be used (e.g., Next Generation Wi-Fi, or other standards). In some embodiments, non-Wi-Fi protocols may be used for communications between devices, such as Bluetooth, dedicated short-range communication (DSRC), Ultra-High Frequency (UHF) (e.g. IEEE 802.11af, IEEE 802.22), white band frequency (e.g., white spaces), or other packetized radio communications. The radio component may include any known receiver and baseband suitable for communicating via the communications protocols. The radio component may further include a low noise amplifier (LNA), additional signal amplifiers, an analog-to-digital (A/D) converter, one or more buffers, and digital baseband.

[0035] In one or more embodiments, and with reference to FIG. **1**, the user devices **120** and the APs **102** may exchange frames **140** to authenticate and associated the user devices **120** to OpenRoaming™ networks provided by the APs **102**. The frames **140** may include beacons indicating the availability of OpenRoaming™ networks, probe requests and responses, authentication requests and responses (e.g., based on activation and user profiles), association requests and responses, and the like.

[0036] FIG. **2**A illustrates an example OpenRoaming™ architecture **200** for device association, in accordance with one or more example embodiments of the present disclosure.

[0037] Referring to FIG. **2**A, a station device (STA) **202** that is pre-provisioned with an activation profile **204** for OpenRoaming™ may detect an AP **206** (e.g., an OpenRoaming™ access network **208** provided by the AP **206**). To authenticate to the OpenRoaming™ access network **208**, a network connector **210** of the access network **208** may perform authentication **212** (e.g., extensible authentication protocol over Radius) of the STA **202**, using the activation profile **204**, with a IdP **214** (e.g., via an identity connector **216** of the IdP **214**). The authentication **212** may be facilitated based on ANP registration **208** with OpenRoaming™ federation **218**, and based on IdP **214** registration with OpenRoaming™ federation **218**. The IdP **214** may be multiple instances of IdPs, each registered with the OpenRoaming™ federation **218**. The network connector **210** may perform an identity provider discovery using a domain name server (DNS) **220**, as IdPs of the IdP **214** may register with the DNS **220** for discovery.

[0038] In one or more embodiments, the STA **202** may be pre-provisioned with the activation profile **204**, which may be a one-time use profile for authenticating the STA **202** to an OpenRoaming™ network without a user needing to generate a user profile in advance of the STA **202** detecting the OpenRoaming™ access network **208**. The IdP **214** may determine that the activation profile **204** has or has not been used for authentication. Once the activation profile **204** has been used once for authentication, the IdP **214** may not authenticate the STA **202** using the activation profile **204**. Instead, the STA **202**, after one authentication use of the activation profile **204**, may prompt a user to generate a new user profile. The IdP **214** may authenticate the STA **202** to any OpenRoaming™ network by using the user profile created with the STA **202**, allowing the STA **202** to seamlessly transition from one OpenRoaming™ network to another as the STA **202** moves to different physical locations. Generation of a new user profile may require user acceptance of certain terms and conditions, and may allow a user to enter a username, password, and other account details (e.g., person's name, address, preferences, etc.). The activation profile **204** may be based on a device identifier, a MAC address, a certificate, and/or a token.

[0039] FIG. **2**B illustrates an example process **250** for out-of-box OpenRoaming™ in-band activation and provisioning, in accordance with one or more example embodiments of the present disclosure.

[0040] Referring to FIG. **2**B, the process **250** may include the STA **202** and the AP **206** of FIG. **2**A, the Internet **252**, the DNS **220** of FIG. **2**A, and the IdP **214** of FIG. **2**A, which may include an account manager **254** and an authentication, authorization, and accounting (AAA) service **256**. At step **260**, the STA **202** may be pre-provisioned (e.g., with the activation profile **204** of FIG. **2**A, an operating system setup or update, etc.). At step **262**, the STA **202** may identify an OpenRoaming™ access network (e.g., the OpenRoaming™ access network **208** of FIG. **2**A) for the first time. At step **264**, the STA **202** may connect to the OpenRoaming™ access network via the AP **206** using the activation profile. The AP/ANP **206** may use the DNS **220** to identify, at step **266**, an IdP for authentication, and at step **268**, may forward the authentication request to the AAA service **256** (e.g., over Radius or RADSec). At step **270**, once the IdP **214** has authenticated the STA **202** using the activation profile, network access may be granted to the STA **202**.

[0041] Still referring to FIG. **2**B, the STA **202** may prompt a user, at step **270**, to generate a new OpenRoaming™ user profile. Once the activation profile has been used to grant access to a network, the STA **202** may require a device user to create a new user profile. At step **274**, a user (e.g., the user **110** of FIG. **1**) may provide profile information, such as a username and password, contact information, and the like, and may accept terms and conditions for use, allowing for generation of the new user profile for OpenRoaming™. At step **276**, the AAA service **256** may update records to include the new user profile for future use. At step **278**, the STA **202** may identify an OpenRoaming™ network. Because the STA **202** has used the activation profile once, the STA **202** may attempt to connect to an OpenRoaming™ network at step **280** using the updated user profile. At step **282**, the AP **206** may use the DNS **220** to identify an IdP address for authentication. At step **284**, the AP **206** may forward the authentication request to the AAA service **256** (e.g., over Radius or RADSec). At step **286**, once the IdP **214** has authenticated the STA **202** using the new user profile, network access may be granted to the STA **202**.

[0042] In one or more embodiments, the ANP (e.g., represented by the AP **206**) may check a provided IdP with the DNS (e.g., steps **266** and **282**). As shown in FIG. **2**A, the IdP **214** may be provided using IdP registration. The ANP may forward the authentication to the AAA service **256** (e.g., steps **268** and **284**), and the IdP **214** may authenticate the STA **202**, passing the authentication result to the ANP (e.g., steps **268** and **284**). When the ANP grants OpenRoaming™ network access (e.g., steps **270** and **286**), the STA **202** has a connection to the Internet **252**.

[0043] In one or more embodiments, the user profile may include a username and password using the extensible authentication protocol (EAP)-tunneled transport layer security (TTLS), other options may be implemented, such as a 509x certificate-based option (EAP-transport layer security).

[0044] It is understood that the above descriptions are for purposes of illustration and are not meant to be limiting.

[0045] FIG. **3** illustrates a flow diagram of illustrative process **300** for enhanced in-band activation and provisioning of devices for OpenRoaming™ networks, in accordance with one or more example embodiments of the present disclosure.

[0046] At block **302**, device (e.g., one of the user devices **120** of FIG. **1**, the STA **202** of FIG. **2**A and FIG. **2**B, the enhanced OpenRoaming device **519** of FIG. **5**) may, as part of a device pre-provisioning process, generate and store an OpenRoaming activation profile (e.g., the activation profile **204** of FIG. **2**A) on the device without requiring user interaction (e.g., pre-install the activation profile prior to sale/purchase of the device).

[0047] At block **304**, the device may identify, after the pre-provisioning, a first OpenRoaming network in range of the device (e.g., step **262** of FIG. **2**B). The network may be identified based on a beacon sent by an AP (e.g., the AP **102** of FIG. **1**, the AP **206** of FIG. **2**A and FIG. **2**B), a probe response sent by the AP, or another indication sent by the AP to communicate the existence of an OpenRoaming network provided by the AP.

[0048] At block **306**, the device may generate and transmit, to the AP, a first authentication request (e.g., step **264** of FIG. **2**B), identifying the activation profile with which to authenticate the device. The activation profile may be for one-time use (e.g., may be used for authentication only once).

[0049] At block **308**, the device may identify an authentication response received from the AP (e.g., step **268** of FIG. **2**B), indicating that the device has been authenticated to the OpenRoaming network based on the activation profile. In this manner, the activation profile allows for a device to authenticate to the first OpenRoaming network that the device detects without the device user needed to create a user profile or otherwise interact with the device to join an OpenRoaming network.

[0050] At block **310**, the device may access the first OpenRoaming network once the device has authenticated and associated to the OpenRoaming network. Accessing the OpenRoaming network may include sending and receiving data over a wireless communication channel provided by the AP.

[0051] At block **312**, the device may generate a user profile for future OpenRoaming use. Because the activation profile may be used to authenticate the device only once (e.g., the first time), the device may prompt the device user to enter user profile information and accept terms and conditions of use once the device determines that the activation profile has been used once for authentication. When the user provides the user profile information, the device may generate the user profile, which may be stored by an identity provider for future authentication use.

[0052] At block **314**, the device may authenticate to and access additional OpenRoaming networks using the user profile. For example, the device may repeat the steps at blocks **304-310**, using the user profile instead of the activation profile. Because the user profile may be used multiple times, as the device detects OpenRoaming networks, the device may authenticate to any OpenRoaming network using the user profile, allowing the user to seamlessly transition between OpenRoaming networks without requiring additional user interaction.

[0053] It is understood that the above descriptions are for purposes of illustration and are not meant to be limiting.

[0054] FIG. **4** shows a functional diagram of an exemplary communication station **400**, in accordance with one or more example embodiments of the present disclosure. In one embodiment, FIG. **4** illustrates a functional block diagram of a communication station that may be suitable for use as an AP **102** (FIG. **1**) or a user device **120** (FIG. **1**) in accordance with some embodiments. The communication station **400** may also be suitable for use as a handheld device, a mobile device, a cellular telephone, a smartphone, a tablet, a netbook, a wireless terminal, a laptop computer, a wearable computer device, a femtocell, a high data rate (HDR) subscriber station, an access point, an access terminal, or other personal communication system (PCS) device.

[0055] The communication station **400** may include communications circuitry **402** and a transceiver **410** for transmitting and receiving signals to and from other communication stations using one or more antennas **401**. The communications circuitry **402** may include circuitry that can operate the physical layer (PHY) communications and/or medium access control (MAC) communications for controlling access to the wireless medium, and/or any other communications layers for transmitting and receiving signals. The communication station **400** may also include processing circuitry **406** and memory **408** arranged to perform the operations described herein. In some embodiments, the communications circuitry **402** and the processing circuitry **406** may be configured to perform operations detailed in the above figures, diagrams, and flows.

[0056] In accordance with some embodiments, the communications circuitry **402** may be arranged to contend for a wireless medium and configure frames or packets for communicating over the wireless medium. The communications circuitry **402** may be arranged to transmit and receive signals. The communications circuitry **402** may also include circuitry for modulation/demodulation, upconversion/downconversion, filtering, amplification, etc. In some embodiments, the processing circuitry **406** of the communication station **400** may include one or more processors. In other embodiments, two or more antennas **401** may be coupled to the communications circuitry **402** arranged for sending and receiving signals. The memory **408** may store information for configuring the processing circuitry **406** to perform operations for configuring and transmitting message frames and performing the various operations described herein. The memory **408** may include any type of memory, including non-transitory memory, for storing information in a form readable by a machine (e.g., a computer). For example, the memory **408** may include a computer-readable storage device, read-only memory (ROM), random-access memory (RAM), magnetic disk storage media, optical storage media, flash-memory devices and other storage devices and media.

[0057] In some embodiments, the communication station **400** may be part of a portable wireless communication device, such as a personal digital assistant (PDA), a laptop or portable computer with wireless communication capability, a web tablet, a wireless telephone, a smartphone, a wireless headset, a pager, an instant messaging device, a digital camera, an access point, a television, a medical device (e.g., a heart rate monitor, a blood pressure monitor, etc.), a wearable computer device, or another device that may receive and/or transmit information wirelessly.

[0058] In some embodiments, the communication station **400** may include one or more antennas **401**. The antennas **401** may include one or more directional or omnidirectional antennas, including, for example, dipole antennas, monopole antennas, patch antennas, loop antennas, microstrip antennas, or other types of antennas suitable for transmission of RF signals. In some embodiments, instead of two or more antennas, a single antenna with multiple apertures may be used. In these embodiments, each aperture may be considered a separate antenna. In some multiple-input multiple-output (MIMO) embodiments, the antennas may be effectively separated for spatial diversity and the different channel characteristics that may result between each of the antennas and the antennas of a transmitting station.

[0059] In some embodiments, the communication station **400** may include one or more of a keyboard, a display, a non-volatile memory port, multiple antennas, a graphics processor, an application processor, speakers, and other mobile device elements. The display may be an LCD screen including a touch screen.

[0060] Although the communication station **400** is illustrated as having several separate functional elements, two or more of the functional elements may be combined and may be implemented by combinations of software-configured elements, such as processing elements including digital signal processors (DSPs), and/or other hardware elements. For example, some elements may include one or more microprocessors, DSPs, field-programmable gate arrays (FPGAs), application specific integrated circuits (ASICs), radio-frequency integrated circuits (RFICs) and combinations of various hardware and logic circuitry for performing at least the functions described herein. In some embodiments, the functional elements of the communication station **400** may refer to one or more processes operating on one or more processing elements.

[0061] Certain embodiments may be implemented in one or a combination of hardware, firmware, and software. Other embodiments may also be implemented as instructions stored on a computer-readable storage device, which may be read and executed by at least one processor to perform the operations described herein. A computer-readable storage device may include any non-transitory memory mechanism for storing information in a form readable by a machine (e.g., a computer). For example, a computer-readable storage device may include read-only memory (ROM), random-access memory (RAM), magnetic disk storage media, optical storage media, flash-memory devices, and other storage devices and media. In some embodiments, the communication station YY00 may include one or more processors and may be configured with instructions stored on a computer-readable storage device.

[0062] FIG. **5** illustrates a block diagram of an example of a machine **500** or system upon which any one or more of the techniques (e.g., methodologies) discussed herein may be performed. In other embodiments, the machine **500** may operate as a standalone device or may be connected (e.g., networked) to other machines. In a networked deployment, the machine **500** may operate in the capacity of a server machine, a client machine, or both in server-client network environments. In an example, the machine **500** may act as a peer machine in peer-to-peer (P2P) (or other distributed) network environments. The machine **500** may be a personal computer (PC), a tablet PC, a set-top box (STB), a personal digital assistant (PDA), a mobile telephone, a wearable computer device, a web appliance, a network router, a switch or bridge, or any machine capable of executing instructions (sequential or otherwise) that specify actions to be taken by that machine, such as a base station. Further, while only a single machine is illustrated, the term "machine" shall also be taken to include any collection of machines that individually or jointly execute a set (or multiple sets) of instructions to perform any one or more of the methodologies discussed herein, such as cloud computing, software as a service (SaaS), or other computer cluster configurations.

[0063] Examples, as described herein, may include or may operate on logic or a number of components, modules, or mechanisms. Modules are tangible entities (e.g., hardware) capable of performing specified operations when operating. A module includes hardware. In an example, the hardware may be specifically configured to carry out a specific operation (e.g., hardwired). In another example, the hardware may include configurable execution units (e.g., transistors, circuits, etc.) and a computer readable medium containing instructions where the instructions configure the execution units to carry out a specific operation when in operation. The configuring may occur under the direction of the executions units or a loading mechanism. Accordingly, the execution units are communicatively coupled to the computer-readable medium when the device is operating. In this example, the execution units may be a member of more than one module. For example, under operation, the execution units may be configured by a first set of instructions to implement a first module at one point in time and reconfigured by a second set of instructions to implement a second module at a second point in time.

[0064] The machine (e.g., computer system) **500** may include a hardware processor **502** (e.g., a central processing unit (CPU), a graphics processing unit (GPU), a hardware processor core, or any combination thereof), a main memory **504** and a static memory **506**, some or all of which may communicate with each other via an interlink (e.g., bus) **508**. The machine **500** may further include a power management device **532**, a graphics display device **510**, an alphanumeric input device **512** (e.g., a keyboard), and a user interface (UI) navigation device **514** (e.g., a mouse). In an example, the graphics display device **510**, alphanumeric input device **512**, and UI navigation device **514** may be a touch screen display. The machine **500** may additionally include a storage device (i.e., drive unit) **516**, a signal generation device **518** (e.g., a speaker), an enhanced OpenRoaming device **519**, a network interface device/transceiver **520** coupled to antenna(s) **530**, and one or more sensors **528**, such as a global positioning system (GPS) sensor, a compass, an accelerometer, or other sensor. The machine **500** may include an output controller **534**, such as a serial (e.g., universal serial bus (USB), parallel, or other wired or wireless (e.g., infrared (IR), near field communication (NFC), etc.) connection to communicate with or control one or more peripheral devices (e.g., a printer, a card reader, etc.)). The operations in accordance with one or more example embodiments of the present disclosure may be carried out by a baseband processor. The baseband processor may be configured to generate corresponding baseband signals. The baseband processor may further include physical layer (PHY) and medium access control layer (MAC) circuitry, and may further interface with the hardware processor **502** for generation and processing of the baseband signals and for controlling operations of the main memory **504**, the storage device **516**, and/or the enhanced OpenRoaming device **519**. The baseband processor may be provided on a single radio card, a single chip, or an integrated circuit (IC).

[0065] The storage device **516** may include a machine readable medium **522** on which is stored one or more sets of data structures or instructions **524** (e.g., software) embodying or utilized by any one or more of the techniques or functions described herein. The instructions **524** may also reside, completely or at least partially, within the main memory **504**, within the static memory **506**, or within the hardware processor **502** during execution thereof by the machine **500**. In an example, one or any combination of the hardware processor **502**, the main memory **504**, the static memory **506**, or the storage device **516** may constitute machine-readable media.

[0066] The enhanced OpenRoaming device **519** may carry out or perform any of the operations and processes (e.g., process **300**) described and shown above.

[0067] It is understood that the above are only a subset of what the enhanced OpenRoaming device **519** may be configured to perform and that other functions included throughout this disclosure may also be performed by the enhanced OpenRoaming device **519**.

[0068] While the machine-readable medium **522** is illustrated as a single medium, the term "machine-readable medium" may include a single medium or multiple media (e.g., a centralized or distributed database, and/or associated caches and servers) configured to store the one or more instructions **524**.

[0069] Various embodiments may be implemented fully or partially in software and/or firmware. This software and/or firmware may take the form of instructions contained in or on a non-transitory computer-readable storage medium. Those instructions may then be read and executed by one or more processors to enable performance of the operations described herein. The instructions may be in any suitable form, such as but not limited to source code, compiled code, interpreted code, executable code, static code, dynamic code, and the like. Such a computer-readable medium may include any tangible non-transitory medium for storing information in a form readable by one or more computers, such as but not limited to read only memory (ROM); random access memory (RAM); magnetic disk storage media; optical storage media; a flash memory, etc.

[0070] The term "machine-readable medium" may include any medium that is capable of storing, encoding, or carrying instructions for execution by the machine **500** and that cause the machine **500** to perform any one or more of the techniques of the present disclosure, or that is capable of storing, encoding, or carrying data structures used by or associated with such instructions. Non-limiting machine-readable medium examples may include solid-state memories and optical and magnetic media. In an example, a massed machine-readable medium includes a machine-readable medium with a plurality of particles having resting mass. Specific examples of massed machine-readable media may include non-volatile memory, such as semiconductor memory devices (e.g., electrically programmable read-only memory (EPROM), or electrically erasable programmable read-only memory (EEPROM)) and flash memory devices; magnetic disks, such as internal hard disks and removable disks; magneto-optical disks; and CD-ROM and DVD-ROM disks.

[0071] The instructions **524** may further be transmitted or received over a communications network **526** using a transmission medium via the network interface device/transceiver **520** utilizing any one of a number of transfer protocols (e.g., frame relay, internet protocol (IP), transmission control protocol (TCP), user datagram protocol (UDP), hypertext transfer protocol (HTTP), etc.). Example communications networks may include a local area network (LAN), a wide area network (WAN), a packet data network (e.g., the Internet), mobile telephone networks (e.g., cellular networks), plain old telephone (POTS) networks, wireless data networks (e.g., Institute of Electrical and Electronics Engineers (IEEE) 802.11 family of standards known as Wi-Fi®, IEEE 802.16 family of standards known as WiMax®), IEEE 802.15.4 family of standards, and peer-to-peer (P2P) networks, among others. In an example, the network interface device/transceiver **520** may include one or more physical jacks (e.g., Ethernet, coaxial, or phone jacks) or one or more antennas to connect to the communications network **526**. In an example, the network interface device/transceiver **520** may include a plurality of antennas to wirelessly communicate using at least one of single-input multiple-output (SIMO), multiple-input multiple-output (MIMO), or multiple-input single-output (MISO) techniques. The term "transmission medium" shall be taken to include any intangible medium that is capable of storing, encoding, or carrying instructions for execution by the machine **500** and includes digital or analog communications signals or other intangible media to facilitate communication of such software.

[0072] The operations and processes described and shown above may be carried out or performed in any suitable order as desired in various implementations. Additionally, in certain implementations, at least a portion of the operations may be carried out in parallel. Furthermore, in certain implementations, less than or more than the operations described may be performed.

[0073] FIG. **6** is a block diagram of a radio architecture **105**A, **105**B in accordance with some embodiments that may be implemented in any one of the example AP **102** and/or the example STA **120** of FIG. **1**. Radio architecture **105**A, **105**B may include radio front-end module (FEM) circuitry XZX04a-b, radio IC circuitry XZX06a-b and baseband processing circuitry XZX08a-b. Radio architecture **105**A, **105**B as shown includes both Wireless Local Area Network (WLAN) functionality and Bluetooth (BT) functionality although embodiments are not so limited. In this disclosure, "WLAN" and "Wi-Fi" are used interchangeably.

[0074] FEM circuitry ***604**a-b* may include a WLAN or Wi-Fi FEM circuitry **604***a* and a Bluetooth (BT) FEM circuitry **604***b*. The WLAN FEM circuitry **604***a* may include a receive signal path comprising circuitry configured to operate on WLAN RF signals received from one or more antennas **601**, to amplify the received signals and to provide the amplified versions of the received signals to the WLAN radio IC circuitry **606***a* for further processing. The BT FEM circuitry **604***b* may include a receive signal path which may include circuitry configured to operate on BT RF signals received from one or more antennas **601**, to amplify the received signals and to provide the amplified versions of the received signals to the BT radio IC circuitry **606***b* for further processing. FEM circuitry **604***a* may also include a transmit signal path which may include circuitry configured to amplify WLAN signals provided by the radio IC circuitry **606***a* for wireless transmission by one or more of the antennas **601**. In addition, FEM circuitry **604***b* may also include a transmit signal path which may include circuitry configured to amplify BT signals provided by the radio IC circuitry **606***b* for wireless transmission by the one or more antennas. In the embodiment of FIG. **6**, although FEM **604***a* and FEM **604***b* are shown as being distinct from one another, embodiments are not so limited, and include within their scope the use of an FEM (not shown) that includes a transmit path and/or a receive path for both WLAN and BT signals, or the use of one or more FEM circuitries where at least some of the FEM circuitries share transmit and/or receive signal paths for both WLAN and BT signals.

[0075] Radio IC circuitry **606***a-b* as shown may include WLAN radio IC circuitry **606***a* and BT radio IC circuitry **606***b*. The WLAN radio IC circuitry **606***a* may include a receive signal path which may include circuitry to down-convert WLAN RF signals received from the FEM circuitry **604***a* and provide baseband signals to WLAN baseband processing circuitry **608***a*. BT radio IC circuitry **606***b* may in turn include a receive signal path which may include circuitry to down-convert BT RF signals received from the FEM circuitry **604***b* and provide baseband signals to BT baseband processing circuitry **608***b*. WLAN radio IC circuitry **606***a* may also include a transmit signal path which may include circuitry to up-convert WLAN baseband signals provided by the WLAN baseband processing circuitry **608***a* and provide WLAN RF output signals to the FEM circuitry **604***a* for subsequent wireless transmission by the one or more antennas **601**. BT radio IC circuitry **606***b* may also include a transmit signal path which may include circuitry to up-convert BT baseband signals provided by the BT baseband processing circuitry **608***b* and provide BT RF output signals to the FEM circuitry **604***b* for subsequent wireless transmission by the one or more antennas **601**. In the embodiment of FIG. **6**, although radio IC circuitries **606***a* and **606***b* are shown as being distinct from one another, embodiments are not so limited, and include within their scope the use of a radio IC circuitry (not shown) that includes a transmit signal path and/or a receive signal path for both WLAN and BT signals, or the use of one or more radio IC circuitries where at least some of the radio IC circuitries share transmit and/or receive signal paths for both WLAN and BT signals.

[0076] Baseband processing circuity **608***a-b* may include a WLAN baseband processing circuitry **608***a* and a BT baseband processing circuitry **608***b*. The WLAN baseband processing circuitry **608***a* may include a memory, such as, for example, a set of RAM arrays in a Fast Fourier Transform or Inverse Fast Fourier Transform block (not shown) of the WLAN baseband processing circuitry **608***a*. Each of the WLAN baseband circuitry **608***a* and the BT baseband circuitry **608***b* may further include one or more processors and control logic to process the signals received from the corresponding WLAN or BT receive signal path of the radio IC circuitry **606***a-b*, and to also generate corresponding WLAN or BT baseband signals for the transmit signal path of the radio IC circuitry **606***a-b*. Each of the baseband processing circuitries **608***a* and **608***b* may further include physical layer (PHY) and medium access control layer (MAC) circuitry, and may further interface with a device for generation and processing of the baseband signals and for controlling operations of the radio IC circuitry **606***a-b*.

[0077] Referring still to FIG. **6**, according to the shown embodiment, WLAN-BT coexistence circuitry **613** may include logic providing an interface between the WLAN baseband circuitry **608***a* and the BT baseband circuitry **608***b* to enable use cases requiring WLAN and BT coexistence. In addition, a switch **603** may be provided between the WLAN FEM circuitry **604***a* and the BT FEM circuitry **604***b* to allow switching between the WLAN and BT radios according to application needs. In addition, although the antennas **601** are depicted as being respectively connected to the WLAN FEM circuitry **604***a* and the BT FEM circuitry **604***b*, embodiments include within their scope the sharing of one or more antennas as between the WLAN and BT FEMs, or the provision of more than one antenna connected to each of FEM **604***a* or **604***b*.

[0078] In some embodiments, the front-end module circuitry **604***a-b*, the radio IC circuitry **606***a-b*, and baseband processing circuitry **608***a-b* may be provided on a single radio card, such as wireless radio card **602**. In some other embodiments, the one or more antennas **601**, the FEM circuitry **604***a-b* and the radio IC circuitry **606***a-b* may be provided on a single radio card. In some other embodiments, the radio IC circuitry **606***a-b* and the baseband processing circuitry **608***a-b* may be provided on a single chip or integrated circuit (IC), such as IC **612**.

[0079] In some embodiments, the wireless radio card **602** may include a WLAN radio card and may be configured for Wi-Fi communications, although the scope of the embodiments is not limited in this respect. In some of these embodiments, the radio architecture **105**A, **105**B may be configured to receive and transmit orthogonal frequency division multiplexed (OFDM) or orthogonal frequency division multiple access (OFDMA) communication signals over a multicarrier communication channel. The OFDM or OFDMA signals may comprise a plurality of orthogonal subcarriers.

[0080] In some of these multicarrier embodiments, radio architecture **105**A, **105**B may be part of a Wi-Fi communication station (STA) such as a wireless access point (AP), a base station or a mobile device including a Wi-Fi device. In some of these embodiments, radio architecture **105**A, **105**B may be configured to transmit and receive signals in accordance with specific communication standards and/or protocols, such as any of the Institute of Electrical and Electronics Engineers (IEEE) standards including, 802.11n-2009, IEEE 802.11-2012, IEEE 802.11-2016, 802.11n-2009, 802.11ac, 802.11ah, 802.11ad, 802.11 ay, 802.11be, and/or 802.11ax standards and/or proposed specifications for WLANs, although the scope of embodiments is not limited in this respect. Radio architecture **105**A, **105**B may also be suitable to transmit and/or receive communications in accordance with other techniques and standards.

[0081] In some embodiments, the radio architecture **105**A, **105**B may be configured for high-efficiency Wi-Fi (HEW) communications in accordance with the IEEE 802.11ax standard. In these embodiments, the radio architecture **105**A, **105**B may be configured to communicate in accordance with an OFDMA technique, although the scope of the embodiments is not limited in this respect.

[0082] In some other embodiments, the radio architecture **105**A, **105**B may be configured to transmit and receive signals transmitted using one or more other modulation techniques such as spread spectrum modulation (e.g., direct sequence code division multiple access (DS-CDMA) and/or frequency hopping code division multiple access (FH-CDMA)), time-division multiplexing (TDM) modulation, and/or frequency-division multiplexing (FDM) modulation, although the scope of the embodiments is not limited in this respect.

[0083] In some embodiments, as further shown in FIG. **6**, the BT baseband circuitry **608***b* may be compliant with a Bluetooth (BT) connectivity standard such as Bluetooth, Bluetooth 8.0 or Bluetooth 6.0, or any other iteration of the Bluetooth Standard.

[0084] In some embodiments, the radio architecture **105**A, **105**B may include other radio cards, such as a cellular radio card configured for cellular (e.g., 5GPP such as LTE, LTE-Advanced or 7G communications).

[0085] In some IEEE 802.11 embodiments, the radio architecture **105**A, **105**B may be configured for communication over various channel bandwidths including bandwidths having center frequencies of about 900 MHz, 2.4 GHz, 5 GHz, and bandwidths of about 2 MHz, 4 MHz, 5 MHz, 5.5 MHz, 6 MHz, 8 MHz, 10 MHz, 20 MHz, 40 MHz, 80 MHz (with contiguous bandwidths) or 80+80 MHz (160 MHz) (with non-contiguous bandwidths). In some embodiments, a 920 MHz channel bandwidth may be used. The scope of the embodiments is not limited with respect to the above center frequencies however.

[0086] FIG. **7** illustrates WLAN FEM circuitry **604***a* in accordance with some embodiments. Although the example of FIG. **7** is described in conjunction with the WLAN FEM circuitry **604***a*, the example of FIG. **7** may be described in conjunction with the example BT FEM circuitry **604***b* (FIG. **6**), although other circuitry configurations may also be suitable.

[0087] In some embodiments, the FEM circuitry **604***a* may include a TX/RX switch **702** to switch between transmit mode and receive mode operation. The FEM circuitry **604***a* may include a receive signal path and a transmit signal path. The receive signal path of the FEM circuitry **604***a* may include a low-noise amplifier (LNA) **706** to amplify received RF signals **703** and provide the amplified received RF signals **707** as an output (e.g., to the radio IC circuitry **606***a-b* (FIG. **6**)). The transmit signal path of the circuitry **604***a* may include a power amplifier (PA) to amplify input RF signals **709** (e.g., provided by the radio IC circuitry **606***a-b*), and one or more filters **712**, such as band-pass filters (BPFs), low-pass filters (LPFs) or other types of filters, to generate RF signals **715** for subsequent transmission (e.g., by one or more of the antennas **601** (FIG. **6**)) via an example duplexer **714**.

[0088] In some dual-mode embodiments for Wi-Fi communication, the FEM circuitry **604***a* may be configured to operate in either the 2.4 GHz frequency spectrum or the 5 GHz frequency spectrum. In these embodiments, the receive signal path of the FEM circuitry **604***a* may include a receive signal path duplexer **704** to separate the signals from each spectrum as well as provide a separate LNA **706** for each spectrum as shown. In these embodiments, the transmit signal path of the FEM circuitry **604***a* may also include a power amplifier **710** and a filter **712**, such as a BPF, an LPF or another type of filter for each frequency spectrum and a transmit signal path duplexer **704** to provide the signals of one of the different spectrums onto a single transmit path for subsequent transmission by the one or more of the antennas **601** (FIG. **6**). In some embodiments, BT communications may utilize the 2.4 GHz signal paths and may utilize the same FEM circuitry **604***a* as the one used for WLAN communications.

[0089] FIG. **8** illustrates radio IC circuitry **606***a* in accordance with some embodiments. The radio IC circuitry **606***a* is one example of circuitry that may be suitable for use as the WLAN or BT radio IC circuitry **606***a*/**606***b* (FIG. **6**), although other circuitry configurations may also be suitable. Alternatively, the example of FIG. **8** may be described in conjunction with the example BT radio IC circuitry **606***b*.

[0090] In some embodiments, the radio IC circuitry **606***a* may include a receive signal path and a transmit signal path. The receive signal path of the radio IC circuitry **606***a* may include at least mixer circuitry **802**, such as, for example, down-conversion mixer circuitry, amplifier circuitry **806** and filter circuitry **808**. The transmit signal path of the radio IC circuitry **606***a* may include at least filter circuitry **812** and mixer circuitry **814**, such as, for example, up-conversion mixer circuitry. Radio IC circuitry **606***a* may also include synthesizer circuitry **804** for synthesizing a frequency **805** for use by the mixer circuitry **802** and the mixer circuitry **814**. The mixer circuitry **802** and/or **814** may each, according to some embodiments, be configured to provide direct conversion functionality. The latter type of circuitry presents a much simpler architecture as compared with standard super-heterodyne mixer circuitries, and any flicker noise brought about by the same may be alleviated for example through the use of OFDM modulation. FIG. **8** illustrates only a simplified version of a radio IC circuitry, and may include, although not shown, embodiments where each of the depicted circuitries may include more than one component. For instance, mixer circuitry **814** may each include one or more mixers, and filter circuitries **808** and/or **812** may each include one or more filters, such as one or more BPFs and/or LPFs according to application needs. For example, when mixer circuitries are of the direct-conversion type, they may each include two or more mixers.

[0091] In some embodiments, mixer circuitry **802** may be configured to down-convert RF signals **707** received from the FEM circuitry **604***a-b* (FIG. **6**) based on the synthesized frequency **805** provided by synthesizer circuitry **804**. The amplifier circuitry **806** may be configured to amplify the down-converted signals and the filter circuitry **808** may include an LPF configured to remove unwanted signals from the down-converted signals to generate output baseband signals **807**. Output baseband signals **807** may be provided to the baseband processing circuitry **608***a-b* (FIG. **6**) for further processing. In some embodiments, the output baseband signals **807** may be zero-frequency baseband signals, although this is not a requirement. In some embodiments, mixer circuitry **802** may comprise passive mixers, although the scope of the embodiments is not limited in this respect.

[0092] In some embodiments, the mixer circuitry **814** may be configured to up-convert input baseband signals **811** based on the synthesized frequency **805** provided by the synthesizer circuitry **804** to generate RF output signals **709** for the FEM circuitry **604***a-b*. The baseband signals **811** may be provided by the baseband processing circuitry **608***a-b* and may be filtered by filter circuitry **812**. The filter circuitry **812** may include an LPF or a BPF, although the scope of the embodiments is not limited in this respect.

[0093] In some embodiments, the mixer circuitry **802** and the mixer circuitry **814** may each include two or more mixers and may be arranged for quadrature down-conversion and/or up-conversion respectively with the help of synthesizer **804**. In some embodiments, the mixer circuitry **802** and the mixer circuitry **814** may each include two or more mixers each configured for image rejection (e.g., Hartley image rejection). In some embodiments, the mixer circuitry **802** and the mixer circuitry **814** may be arranged for direct down-conversion and/or direct up-conversion, respectively. In some embodiments, the mixer circuitry **802** and the mixer circuitry **814** may be configured for super-heterodyne operation, although this is not a requirement.

[0094] Mixer circuitry **802** may comprise, according to one embodiment: quadrature passive mixers (e.g., for the in-phase (I) and quadrature phase (Q) paths). In such an embodiment, RF input signal **707** from FIG. **8** may be down-converted to provide I and Q baseband output signals to be sent to the baseband processor.

[0095] Quadrature passive mixers may be driven by zero and ninety-degree time-varying LO switching signals provided by a quadrature circuitry which may be configured to receive a LO frequency (fLO) from a local oscillator or a synthesizer, such as LO frequency **805** of synthesizer **804** (FIG. **8**). In some embodiments, the LO frequency may be the carrier frequency, while in other embodiments, the LO frequency may be a fraction of the carrier frequency (e.g., one-half the carrier frequency, one-third the carrier frequency). In some embodiments, the zero and ninety-degree time-varying switching signals may be generated by the synthesizer, although the scope of the embodiments is not limited in this respect.

[0096] In some embodiments, the LO signals may differ in duty cycle (the percentage of one period in which the LO signal is high) and/or offset (the difference between start points of the period). In some embodiments, the LO signals may have an 85% duty cycle and an 80% offset. In some embodiments, each branch of the mixer circuitry (e.g., the in-phase (I) and quadrature phase (Q) path) may operate at an 80% duty cycle, which may result in a significant reduction is power consumption.

[0097] The RF input signal **707** (FIG. **7**) may comprise a balanced signal, although the scope of the embodiments is not limited in this respect. The I and Q baseband output signals may be provided to low-noise amplifier, such as amplifier circuitry **806** (FIG. **8**) or to filter circuitry **808** (FIG. **8**).

[0098] In some embodiments, the output baseband signals **807** and the input baseband signals **811** may be analog baseband signals, although the scope of the embodiments is not limited in this respect. In some alternate embodiments, the output baseband signals **807** and the input baseband signals **811** may be digital baseband signals. In these alternate embodiments, the radio IC circuitry may include analog-to-digital converter (ADC) and digital-to-analog converter (DAC) circuitry.

[0099] In some dual-mode embodiments, a separate radio IC circuitry may be provided for processing signals for each spectrum, or for other spectrums not mentioned here, although the scope of the embodiments is not limited in this respect.

[0100] In some embodiments, the synthesizer circuitry **804** may be a fractional-N synthesizer or a fractional N/N+1 synthesizer, although the scope of the embodiments is not limited in this respect as other types of frequency synthesizers may be suitable. For example, synthesizer circuitry **804** may be a delta-sigma synthesizer, a frequency multiplier, or a synthesizer comprising a phase-locked loop with a frequency divider. According to some embodiments, the synthesizer circuitry **804** may include digital synthesizer circuitry. An advantage of using a digital synthesizer circuitry is that, although it may still include some analog components, its footprint may be scaled down much more than the footprint of an analog synthesizer circuitry. In some embodiments, frequency input into synthesizer circuity **804** may be provided by a voltage controlled oscillator (VCO), although that is not a requirement. A divider control input may further be provided by either the baseband processing circuitry **608***a-b* (FIG. **6**) depending on the desired output frequency **805**. In some embodiments, a divider control input (e.g., N) may be determined from a look-up table (e.g., within a Wi-Fi card) based on a channel number and a channel center frequency as determined or indicated by the example application processor **610**. The application processor **610** may include, or otherwise be connected to, one of the example secure signal converter **101** or the example received signal converter **103** (e.g., depending on which device the example radio architecture is implemented in).

[0101] In some embodiments, synthesizer circuitry **804** may be configured to generate a carrier frequency as the output frequency **805**, while in other embodiments, the output frequency **805** may be a fraction of the carrier frequency (e.g., one-half the carrier frequency, one-third the carrier frequency). In some embodiments, the output frequency **805** may be a LO frequency (fLO).

[0102] FIG. **9** illustrates a functional block diagram of baseband processing circuitry **608***a* in accordance with some embodiments. The baseband processing circuitry **608***a* is one example of circuitry that may be suitable for use as the baseband processing circuitry **608***a* (FIG. **6**), although other circuitry configurations may also be suitable. Alternatively, the example of FIG. **8** may be used to implement the example BT baseband processing circuitry **608***b* of FIG. **6**.

[0103] The baseband processing circuitry **608***a* may include a receive baseband processor (RX BBP) **902** for processing receive baseband signals **809** provided by the radio IC circuitry **606***a-b* (FIG. **6**) and a transmit baseband processor (TX BBP) **904** for generating transmit baseband signals **811** for the radio IC circuitry **606***a-b*. The baseband processing circuitry **608***a* may also include control logic **906** for coordinating the operations of the baseband processing circuitry **608***a*.

[0104] In some embodiments (e.g., when analog baseband signals are exchanged between the baseband processing circuitry **608***a-b* and the radio IC circuitry **606***a-b*), the baseband processing circuitry **608***a* may include ADC **910** to convert analog baseband signals **909** received from the radio IC circuitry XZX06a-b to digital baseband signals for processing by the RX BBP ZZZ02. In these embodiments, the baseband processing circuitry **608***a* may also include DAC **912** to convert digital baseband signals from the TX BBP **904** to analog baseband signals **911**.

[0105] In some embodiments that communicate OFDM signals or OFDMA signals, such as through baseband processor **608***a*, the transmit baseband processor **904** may be configured to generate OFDM or OFDMA signals as appropriate for transmission by performing an inverse fast Fourier transform (IFFT). The receive baseband processor **902** may be configured to process received OFDM signals or OFDMA signals by performing an FFT. In some embodiments, the receive baseband processor **902** may be configured to detect the presence of an OFDM signal or OFDMA signal by performing an autocorrelation, to detect a preamble, such as a short preamble, and by performing a cross-correlation, to detect a long preamble. The preambles may be part of a predetermined frame structure for Wi-Fi communication.

[0106] Referring back to FIG. **6**, in some embodiments, the antennas **601** (FIG. **6**) may each comprise one or more directional or omnidirectional antennas, including, for example, dipole antennas, monopole antennas, patch antennas, loop antennas, microstrip antennas or other types of antennas suitable for transmission of RF signals. In some multiple-input multiple-output (MIMO) embodiments, the antennas may be effectively separated to take advantage of spatial diversity and the different channel characteristics that may result. Antennas **601** may each include a set of phased-array antennas, although embodiments are not so limited.

[0107] Although the radio architecture **105**A, **105**B is illustrated as having several separate functional elements, one or more of the functional elements may be combined and may be implemented by combinations of software-configured elements, such as processing elements including digital signal processors (DSPs), and/or other hardware elements. For example, some elements may comprise one or more microprocessors, DSPs, field-programmable gate arrays (FPGAs), application specific integrated circuits (ASICs), radio-frequency integrated circuits (RFICs) and combinations of various hardware and logic circuitry for performing at least the functions described herein. In some embodiments, the functional elements may refer to one or more processes operating on one or more processing elements.

[0108] The word “exemplary” is used herein to mean “serving as an example, instance, or illustration.” Any embodiment described herein as “exemplary” is not necessarily to be construed as preferred or advantageous over other embodiments. The terms “computing device,” “user device,” “communication station,” “station,” “handheld device,” “mobile device,” “wireless device” and “user equipment” (UE) as used herein refers to a wireless communication device such as a cellular telephone, a smartphone, a tablet, a netbook, a wireless terminal, a laptop computer, a femtocell, a high data rate (HDR) subscriber station, an access point, a printer, a point of sale device, an access terminal, or other personal communication system (PCS) device. The device may be either mobile or stationary.

[0109] As used within this document, the term “communicate” is intended to include transmitting, or receiving, or both transmitting and receiving. This may be particularly useful in claims when describing the organization of data that is being transmitted by one device and received by another, but only the functionality of one of those devices is required to infringe the claim. Similarly, the bidirectional exchange of data between two devices (both devices transmit and receive during the exchange) may be described as “communicating,” when only the functionality of one of those devices is being claimed. The term “communicating” as used herein with respect to a wireless communication signal includes transmitting the wireless communication signal and/or receiving the wireless communication signal. For example, a wireless communication unit, which is capable of communicating a wireless communication signal, may include a wireless transmitter to transmit the wireless communication signal to at least one other wireless communication unit, and/or a wireless communication receiver to receive the wireless communication signal from at least one other wireless communication unit.

[0110] As used herein, unless otherwise specified, the use of the ordinal adjectives “first,” “second,” “third,” etc., to describe a common object, merely indicates that different instances of like objects are being referred to and are not intended to imply that the objects so described must be in a given sequence, either temporally, spatially, in ranking, or in any other manner.

[0111] The term “access point” (AP) as used herein may be a fixed station. An access point may also be referred to as an access node, a base station, an evolved node B (eNodeB), or some other similar terminology known in the art. An access terminal may also be called a mobile station, user equipment (UE), a wireless communication device, or some other similar terminology known in the art. Embodiments disclosed herein generally pertain to wireless networks. Some embodiments may relate to wireless networks that operate in accordance with one of the IEEE 802.11 standards.

[0112] Some embodiments may be used in conjunction with various devices and systems, for example, a personal computer (PC), a desktop computer, a mobile computer, a laptop computer, a notebook computer, a tablet computer, a server computer, a handheld computer, a handheld device, a personal digital assistant (PDA) device, a handheld PDA device, an on-board device, an off-board device, a hybrid device, a vehicular device, a non-vehicular device, a mobile or portable device, a consumer device, a non-mobile or non-portable device, a wireless communication station, a wireless communication device, a wireless access point (AP), a wired or wireless router, a wired or wireless modem, a video device, an audio device, an audio-video (A/V) device, a wired or wireless network, a wireless area network, a wireless video area network (WVAN), a local area network (LAN), a wireless LAN (WLAN), a personal area network (PAN), a wireless PAN (WPAN), and the like.

[0113] Some embodiments may be used in conjunction with one way and/or two-way radio communication systems, cellular radio-telephone communication systems, a mobile phone, a cellular telephone, a wireless telephone, a personal communication system (PCS) device, a PDA device which incorporates a wireless communication device, a mobile or portable global positioning system (GPS) device, a device which incorporates a GPS receiver or transceiver or chip, a device which incorporates an RFID element or chip, a multiple input multiple output (MIMO) transceiver or device, a single input multiple output (SIMO) transceiver or device, a multiple input single output (MISO) transceiver or device, a device having one or more internal antennas and/or external antennas, digital video broadcast (DVB) devices or systems, multi-standard radio devices or systems, a wired or wireless handheld device, e.g., a smartphone, a wireless application protocol (WAP) device, or the like.

[0114] Some embodiments may be used in conjunction with one or more types of wireless communication signals and/or systems following one or more wireless communication protocols, for example, radio frequency (RF), infrared (IR), frequency-division multiplexing (FDM), orthogonal FDM (OFDM), time-division multiplexing (TDM), time-division multiple access (TDMA), extended TDMA (E-TDMA), general packet radio service (GPRS), extended GPRS, code-division multiple access (CDMA), wideband CDMA (WCDMA), CDMA 2000, single-carrier CDMA, multi-carrier CDMA, multi-carrier modulation (MDM), discrete multi-tone (DMT), Bluetooth®, global positioning system (GPS), Wi-Fi, Wi-Max, ZigBee, ultra-wideband (UWB), global system for mobile communications (GSM), 2G, 2.5G, 3G, 3.5G, 4G, fifth generation (5G) mobile networks, 3GPP, long term evolution (LTE), LTE advanced, enhanced data rates for GSM Evolution (EDGE), or the like. Other embodiments may be used in various other devices, systems, and/or networks.

[0115] The following examples pertain to further embodiments. Example 1 may be an apparatus of a station device (STA) for use with OpenRoaming networks, the apparatus comprising processing circuitry coupled to storage, the processing circuitry configured to: generate, during a pre-provisioning process, an activation profile on the STA for one-time use with OpenRoaming networks; identify, after the pre-provisioning process, a first OpenRoaming network within range of the STA; transmit, to a first access point (AP), a first authentication request for the first OpenRoaming network, the first authentication request comprising an indication of the activation profile; identify a first authentication response received from the first AP, the first authentication request granting access of the STA to the first OpenRoaming network; and access the first OpenRoaming network based on the first authentication response.

[0116] Example 2 may include the apparatus of example 1 and/or some other example herein, wherein the activation profile is generated based on at least one of a device identifier of the STA, a medium access control (MAC) address of the STA, a certificate, or a token.

[0117] Example 3 may include the apparatus of example 1 and/or some other example herein, wherein the activation profile is indicative of an identity provider, wherein the first authentication request is associated with a domain name server lookup of the identity provider, and wherein the first authentication response is transmitted by the identity provider.

[0118] Example 4 may include the apparatus of example 1 and/or some other example herein, wherein the activation profile is generated without user interaction with the STA.

[0119] Example 5 may include the apparatus of example 1 and/or some other example herein, wherein the processing circuitry is further configured to: determine, based on the first authentication response, that the activation profile has been used once; generate, based on the determination that the activation profile has been used once, a user prompt associated with generating a user profile for use with the OpenRoaming networks; and generate, based on a user input, the user profile on the STA.

[0120] Example 6 may include the apparatus of example 5 and/or some other example herein, wherein the processing circuitry is further configured to: identify, after generating the user profile, in the first OpenRoaming network within range of the STA; after the user profile is provisioned on the STA, disassociate from the first OpenRoaming network; reassociate to the first OpenRoaming network using the user profile; transmit, to the first access point (AP), a second authentication request for the first OpenRoaming network, the second authentication request comprising an indication of the user profile; identify a second authentication response received from the first AP, the second authentication request granting access of the STA to the first OpenRoaming network; and access the first OpenRoaming network based on the second authentication response.

[0121] Example 7 may include the device of example 1 and/or some other example herein, further comprising a transceiver configured to transmit and receive wireless signals comprising the first authentication request and the first authentication response.

[0122] Example 8 may include the device of example 7 and/or some other example herein, further comprising one or more antennas coupled to the transceiver.

[0123] Example 9 may include computer-readable storage medium comprising instructions to cause processing circuitry of a station device (STA), upon execution of the instructions by the processing circuitry, to: generate, during a pre-provisioning process, an activation profile on the STA for one-time use with OpenRoaming networks; identify, after the pre-provisioning process, a first OpenRoaming network within range of the STA; transmit, to a first access point (AP), a first authentication request for the first OpenRoaming network, the first authentication request comprising an indication of the activation profile; identify a first authentication response received from the first AP, the first authentication request granting access of the STA to the first OpenRoaming network; and access the first OpenRoaming network based on the first authentication response.

[0124] Example 10 may include the computer-readable medium of example 9 and/or some other example herein, wherein the activation profile is generated based on at least one of a device identifier of the STA, a medium access control (MAC) address of the STA, a certificate, or a token.

[0125] Example 11 may include the computer-readable medium of example 9 and/or some other example herein, wherein the activation profile is indicative of an identity provider, wherein the first authentication request is associated with a domain name server lookup of the identity provider, and wherein the first authentication response is transmitted by the identity provider.

[0126] Example 12 may include the computer-readable medium of example 9 and/or some other example herein, wherein the activation profile is generated without user interaction with the STA.

[0127] Example 13 may include the computer-readable medium of example 9 and/or some other example herein, wherein execution of the instructions further cause the processing circuitry to: determine, based on the first authentication response, that the activation profile has been used once; generate, based on the determination that the activation profile has been used once, a user prompt associated with generating a user profile for use with the OpenRoaming networks; and generate, based on a user input, the user profile on the STA.

[0128] Example 14 may include the computer-readable medium of example 13 and/or some other example herein, wherein execution of the instructions further cause the processing circuitry to: dis-associate, after generating the user profile, from the first OpenRoaming network; re-associate to the first OpenRoaming network using the user profile; transmit, to the first access point (AP), a second authentication request for the first OpenRoaming network, the second authentication request comprising an indication of the user profile; identify a second authentication response received from the first AP, the second authentication request granting access of the STA to the first OpenRoaming network; and access the first OpenRoaming network based on the second authentication response.

[0129] Example 15 may include a method for using OpenRoaming networks, the method comprising: generating, by processing circuitry of a station device (STA), during a pre-provisioning process, an activation profile on the STA for one-time use with OpenRoaming networks; identifying, by the processing circuitry, after the pre-provisioning process, a first OpenRoaming network within range of the STA; transmitting, by the processing circuitry, to a first access point (AP), a first authentication request for the first OpenRoaming network, the first authentication request comprising an indication of the activation profile; identifying, by the processing circuitry, a first authentication response received from the first AP, the first authentication request granting access of the STA to the first OpenRoaming network; and accessing, by the processing circuitry, the first OpenRoaming network based on the first authentication response.

[0130] Example 16 may include the method of example 15 and/or some other example herein, wherein the activation profile is generated based on at least one of a device identifier of the STA, a medium access control (MAC) address of the STA, a certificate, or a token.

[0131] Example 17 may include the method of example 15 and/or some other example herein, wherein the activation profile is indicative of an identity provider, wherein the first authentication request is associated with a domain name server lookup of the identity provider, and wherein the first authentication response is transmitted by the identity provider.

[0132] Example 18 may include the method of example 15 and/or some other example herein, wherein the activation profile is generated without user interaction with the STA.

[0133] Example 19 may include the method of example 15 and/or some other example herein, further comprising: determining, based on the first authentication response, that the activation profile has been used once; generating, based on the determination that the activation profile has been used once, a user prompt associated with generating a user profile for use with the OpenRoaming networks; and generating, based on a user input, the user profile on the STA.

[0134] Example, 20 may include the method of example 19 and/or some other example herein, further comprising: disassociating from, after generating the user profile, the first OpenRoaming network; re-associating to the first OpenRoaming network using the user profile; transmitting, to the first access point (AP), a second authentication request for the first OpenRoaming network, the second authentication request comprising an indication of the user profile; identifying a second authentication response received from the first AP, the second authentication request granting access of the STA to the first OpenRoaming network; and accessing the first OpenRoaming network based on the second authentication response.

[0135] Example 21 may include an apparatus comprising means for: generating, by a station device (STA), during a pre-provisioning process, an activation profile on the STA for one-time use with OpenRoaming networks; identifying, after the pre-provisioning process, a first OpenRoaming network within range of the STA; transmitting, to a first access point (AP), a first authentication request for the first OpenRoaming network, the first authentication request comprising an indication of the activation profile; identifying a first authentication response received from the first AP, the first authentication request granting access of the STA to the first OpenRoaming network; and accessing the first OpenRoaming network based on the first authentication response.

[0136] Example 22 may include one or more non-transitory computer-readable media comprising instructions to cause an electronic device, upon execution of the instructions by one or more processors of the electronic device, to perform one or more elements of a method described in or related to any of examples 1-21, or any other method or process described herein.

[0137] Example 23 may include an apparatus comprising logic, modules, and/or circuitry to perform one or more elements of a method described in or related to any of examples 1-21, or any other method or process described herein.

[0138] Example 24 may include a method, technique, or process as described in or related to any of examples 1-21, or portions or parts thereof.

[0139] Example 25 may include an apparatus comprising: one or more processors and one or more computer readable media comprising instructions that, when executed by the one or more processors, cause the one or more processors to perform the method, techniques, or process as described in or related to any of examples 1-21, or portions thereof.

[0140] Example 26 may include a method of communicating in a wireless network as shown and described herein.

[0141] Example 27 may include a system for providing wireless communication as shown and described herein.

[0142] Example 28 may include a device for providing wireless communication as shown and described herein.

[0143] Embodiments according to the disclosure are in particular disclosed in the attached claims directed to a method, a storage medium, a device and a computer program product, wherein any feature mentioned in one claim category, e.g., method, can be claimed in another claim category, e.g., system, as well. The dependencies or references back in the attached claims are chosen for formal reasons only. However, any subject matter resulting from a deliberate reference back to any previous claims (in particular multiple dependencies) can be claimed as well, so that any combination of claims and the features thereof are disclosed and can be claimed regardless of the dependencies chosen in the attached claims. The subject-matter which can be claimed comprises not only the combinations of features as set out in the attached claims but also any other combination of features in the claims, wherein each feature mentioned in the claims can be combined with any other feature or combination of other features in the claims. Furthermore, any of the embodiments and features described or depicted herein can be claimed in a separate claim and/or in any combination with any embodiment or feature described or depicted herein or with any of the features of the attached claims.

[0144] The foregoing description of one or more implementations provides illustration and description, but is not intended to be exhaustive or to limit the scope of embodiments to the precise form disclosed. Modifications and variations are possible in light of the above teachings or may be acquired from practice of various embodiments.

[0145] Certain aspects of the disclosure are described above with reference to block and flow diagrams of systems, methods, apparatuses, and/or computer program products according to various implementations. It will be understood that one or more blocks of the block diagrams and flow diagrams, and combinations of blocks in the block diagrams and the flow diagrams, respectively, may be implemented by computer-executable program instructions. Likewise, some blocks of the block diagrams and flow diagrams may not necessarily need to be performed in the order presented, or may not necessarily need to be performed at all, according to some implementations.

[0146] These computer-executable program instructions may be loaded onto a special-purpose computer or other particular machine, a processor, or other programmable data processing apparatus to produce a particular machine, such that the instructions that execute on the computer, processor, or other programmable data processing apparatus create means for implementing one or more functions specified in the flow diagram block or blocks. These computer program instructions may also be stored in a computer-readable storage media or memory that may direct a computer or other programmable data processing apparatus to function in a particular manner, such that the instructions stored in the computer-readable storage media produce an article of manufacture including instruction means that implement one or more functions specified in the flow diagram block or blocks. As an example, certain implementations may provide for a computer program product, comprising a computer-readable storage medium having a computer-readable program code or program instructions implemented therein, said computer-readable program code adapted to be executed to implement one or more functions specified in the flow diagram block or blocks. The computer program instructions may also be loaded onto a computer or other programmable data processing apparatus to cause a series of operational elements or steps to be performed on the computer or other programmable apparatus to produce a computer-implemented process such that the instructions that execute on the computer or other programmable apparatus provide elements or steps for implementing the functions specified in the flow diagram block or blocks.

[0147] Accordingly, blocks of the block diagrams and flow diagrams support combinations of means for performing the specified functions, combinations of elements or steps for performing the specified functions and program instruction means for performing the specified functions. It will also be understood that each block of the block diagrams and flow diagrams, and combinations of blocks in the block diagrams and flow diagrams, may be implemented by special-purpose, hardware-based computer systems that perform the specified functions, elements or steps, or combinations of special-purpose hardware and computer instructions.

[0148] Conditional language, such as, among others, "can," "could," "might," or "may," unless specifically stated otherwise, or otherwise understood within the context as used, is generally intended to convey that certain implementations could include, while other implementations do not include, certain features, elements, and/or operations. Thus, such conditional language is not generally intended to imply that features, elements, and/or operations are in any way required for one or more implementations or that one or more implementations necessarily include logic for deciding, with or without user input or prompting, whether these features, elements, and/or operations are included or are to be performed in any particular implementation.

[0149] Many modifications and other implementations of the disclosure set forth herein will be apparent having the benefit of the teachings presented in the foregoing descriptions and the associated drawings. Therefore, it is to be understood that the disclosure is not to be limited to the specific implementations disclosed and that modifications and other implementations are intended to be included within the scope of the appended claims. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation.

What is claimed is:

1. An apparatus of a station device (STA) for use with OpenRoaming networks, the apparatus comprising processing circuitry coupled to storage, the processing circuitry configured to:
- generate, during a pre-provisioning process, an activation profile on the STA for one-time use with OpenRoaming networks;
- identify, after the pre-provisioning process, a first OpenRoaming network within range of the STA;
- transmit, to a first access point (AP), a first authentication request for the first OpenRoaming network, the first authentication request comprising an indication of the activation profile;
- identify a first authentication response received from the first AP, the first authentication request granting access of the STA to the first OpenRoaming network; and
- access the first OpenRoaming network based on the first authentication response.

2. The apparatus of claim **1**, wherein the activation profile is generated based on at least one of a device identifier of the STA, a medium access control (MAC) address of the STA, a certificate, or a token.

3. The apparatus of claim **1**, wherein the activation profile is indicative of an identity provider, wherein the first authentication request is associated with a domain name server lookup of the identity provider, and wherein the first authentication response is transmitted by the identity provider.

4. The apparatus of claim **1**, wherein the activation profile is generated without user interaction with the STA.

5. The apparatus of claim **1**, wherein the processing circuitry is further configured to:
- determine, based on the first authentication response, that the activation profile has been used once;
- generate, based on the determination that the activation profile has been used once, a user prompt associated with generating a user profile for use with the OpenRoaming networks; and
- generate, based on a user input, the user profile on the STA.

6. The apparatus of claim **5**, wherein the processing circuitry is further configured to:
- identify, after generating the user profile, in the first OpenRoaming network within range of the STA;
- after the user profile is provisioned on the STA, disassociate from the first OpenRoaming network;
- reassociate to the first OpenRoaming network using the user profile;
- transmit, to the first access point (AP), a second authentication request for the first OpenRoaming network, the second authentication request comprising an indication of the user profile;
- identify a second authentication response received from the first AP, the second authentication request granting access of the STA to the first OpenRoaming network; and
- access the first OpenRoaming network based on the second authentication response.

7. The apparatus of claim **1**, further comprising a transceiver configured to transmit and receive wireless signals comprising the first authentication request and the first authentication response.

8. The apparatus of claim **7**, further comprising an antenna coupled to the transceiver.

9. A computer-readable storage medium comprising instructions to cause processing circuitry of a station device (STA), upon execution of the instructions by the processing circuitry, to:
- generate, during a pre-provisioning process, an activation profile on the STA for one-time use with OpenRoaming networks;
- identify, after the pre-provisioning process, a first OpenRoaming network within range of the STA;
- transmit, to a first access point (AP), a first authentication request for the first OpenRoaming network, the first authentication request comprising an indication of the activation profile;
- identify a first authentication response received from the first AP, the first authentication request granting access of the STA to the first OpenRoaming network; and
- access the first OpenRoaming network based on the first authentication response.

10. The computer-readable medium of claim **9**, wherein the activation profile is generated based on at least one of a device identifier of the STA, a medium access control (MAC) address of the STA, a certificate, or a token.

11. The computer-readable medium of claim **9**, wherein the activation profile is indicative of an identity provider, wherein the first authentication request is associated with a domain name server lookup of the identity provider, and wherein the first authentication response is transmitted by the identity provider.

12. The computer-readable medium of claim **9**, wherein the activation profile is generated without user interaction with the STA.

13. The computer-readable medium of claim **9**, wherein execution of the instructions further cause the processing circuitry to:

determine, based on the first authentication response, that the activation profile has been used once;

generate, based on the determination that the activation profile has been used once, a user prompt associated with generating a user profile for use with the OpenRoaming networks; and

generate, based on a user input, the user profile on the STA.

14. The computer-readable medium of claim **13**, wherein execution of the instructions further cause the processing circuitry to:

dis-associate, after generating the user profile, from the first OpenRoaming network;

re-associate to the first OpenRoaming network using the user profile;

transmit, to the first access point (AP), a second authentication request for the first OpenRoaming network, the second authentication request comprising an indication of the user profile;

identify a second authentication response received from the first AP, the second authentication request granting access of the STA to the first OpenRoaming network; and

access the first OpenRoaming network based on the second authentication response.

15. A method for using OpenRoaming networks, the method comprising:

generating, by processing circuitry of a station device (STA), during a pre-provisioning process, an activation profile on the STA for one-time use with OpenRoaming networks;

identifying, by the processing circuitry, after the pre-provisioning process, a first OpenRoaming network within range of the STA;

transmitting, by the processing circuitry, to a first access point (AP), a first authentication request for the first OpenRoaming network, the first authentication request comprising an indication of the activation profile;

identifying, by the processing circuitry, a first authentication response received from the first AP, the first authentication request granting access of the STA to the first OpenRoaming network; and

accessing, by the processing circuitry, the first OpenRoaming network based on the first authentication response.

16. The method of claim **15**, wherein the activation profile is generated based on at least one of a device identifier of the STA, a medium access control (MAC) address of the STA, a certificate, or a token.

17. The method of claim **15**, wherein the activation profile is indicative of an identity provider, wherein the first authentication request is associated with a domain name server lookup of the identity provider, and wherein the first authentication response is transmitted by the identity provider.

18. The method of claim **15**, wherein the activation profile is generated without user interaction with the STA.

19. The method of claim **15**, further comprising:

determining, based on the first authentication response, that the activation profile has been used once;

generating, based on the determination that the activation profile has been used once, a user prompt associated with generating a user profile for use with the OpenRoaming networks; and

generating, based on a user input, the user profile on the STA.

20. The method of claim **19**, further comprising:

disassociating from, after generating the user profile, the first OpenRoaming network;

re-associating to the first OpenRoaming network using the user profile;

transmitting, to the first access point (AP), a second authentication request for the first OpenRoaming network, the second authentication request comprising an indication of the user profile;

identifying a second authentication response received from the first AP, the second authentication request granting access of the STA to the first OpenRoaming network; and

accessing the first OpenRoaming network based on the second authentication response.

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